REMARKS

A. Status of the Claims

Claims 9-18 were pending at the time of the Action. Claim 9 has been amended to correct a typographical error. New claims 19-21 have been added. Thus, claims 9-21 are currently pending. Because the amendment to claim 9 merely corrected a typographical error recognized by the examiner (*see* Action, p. 4) and the new claims merely recite a narrower subset of the antioxidants A and antioxidants B recited in claim 9, any new grounds for rejection cannot be based on Applicant's amendment. Thus, it would be improper for a subsequent Office Action to be made final if it includes any new grounds for rejection. *See* MPEP § 706.07(a).

B. Oath/Declaration

The Action asserts that a new oath or declaration is required because the declaration as filed in the application is not in the English language. This assertion is incorrect. The present application is a U.S. nationalization of a PCT application under 35 U.S.C. § 371, and a declaration in accordance with PCT Rule 4.17(iv) was provided. 37 C.F.R. § 1.69(b) states that in a U.S. nationalization of a PCT application under 35 U.S.C. § 371, a translation is not required of a declaration provided in accordance with PCT Rule 4.17(iv).

C. The Claims Satisfy the Requirements of 35 U.S.C. § 112, ¶ 1 and 2

The Action rejects claims 9-18 under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement, and under 35 U.S.C. § 112, second paragraph, as being indefinite. The Action's asserted basis for both rejections is that the specification does not define the chemical names for the antioxidants represented by the abbreviations NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH. Applicant traverses these rejections.

A proper evaluation of claims 9-18 under the second paragraph of 35 U.S.C. § 112 requires that the claims be read in light of the specification as interpreted by one of ordinary skill

in the art. *North Am. Vaccine, Inc. v. American Cyanamid Co.*, 7 F.3d 1571, 1579, 28 USPQ 2d 1333, 1339 (Fed. Cir. 1993). Whether a claim satisfies the written description requirement of the first paragraph of 35 U.S.C. § 112 is likewise determined from the perspective of a person of ordinary skill in the art. To satisfy the written description requirement, a patent specification must describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventors had possession of the claimed invention. *Vas-Cath, Inc. v. Mahurkar*, 935 F.2d 1555, 1563 (Fed. Cir. 1991). The current claims satisfy the requirements of 35 U.S.C. § 112, first and second paragraphs.

1. Well-Known Terms of Art Do Not Require Detailed Definitions

Use of well-known terms of art in the specification without detailed definitions does not render claims utilizing that same language indefinite. *W.L. Gore & Assoc., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1556-58 (Fed. Cir. 1983). Claims may, therefore, make use of the language understood by those of skill in the art without additional, detailed definitions in the written description. *Id.* As described in more detail below, the terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are well-known terms that are readily understood by those in the art. Thus, these terms do not require detailed definitions in the specification.

2. The Terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH Would Be Understood by Any Person Who Has Taken an Entry-Level Biochemistry Course

The Action clearly failed to examine the claims from the perspective of a person of ordinary skill in the art, as the terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are well-known terms that are readily understood by those in the art. In fact, these terms would even be understood by those who have only taken an entry-level biochemistry course.

NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are commonly used abbreviations for nicotinamide adenine dinucleotide, reduced form; nicotinamide adenine

dinucleotide phosphate, reduced form; flavin adenine dinucleotide, reduced form; flavin mononucleotide, reduced form; flavin adenine dinucleotide, radical form; and flavin mononucleotide, radical form; respectively. It is readily apparent from standard biochemistry text books that these abbreviations are commonly used and understood in the art. For example, attached as Exhibit B to the Declaration of Dr. Pfannhauser ("Pfannhauser Declaration") (attached as Appendix A to this paper) is a table entitled "Some Common Biochemical Abbreviations" from Voet & Voet, BIOCHEMISTRY, 2d Ed., (John Wiley & Sons, Inc., 1995), which shows that NADH, NADPH, $FADH_2$, FADH, and FMN are well-known abbreviations in biochemistry. In fact, such abbreviations are used preferentially in Voet & Voet. If a person were to look up, for example, "nicotinamide adenine dinucleotide, reduced form" in the index of Voet & Voet that person would be directed to "*see* NADH." The same is true of NADPH, $FADH_2$, FADH, and FMN. A highlighted copy of the relevant pages of the index is attached as Exhibit C to the Pfannhauser Declaration. Although the reduced and radical forms of FMN are not listed in the index, the terms $FMNH_2$ and FMNH are used in Voet & Voet at, for example, page 575 (Exhibit D to the Pfannhauser Declaration). Another undergraduate-level biochemistry text, Streyer, BIOCHEMISTRY, 3d Ed. (W.H. Freeman and Co., 1988) contains a table entitled "Common Abbreviations in Biochemistry," which lists NADH, NADPH, $FADH_2$, $FMNH_2$, FAD, and FMN. A copy of this table is attached as Exhibit E to the Pfannhauser Declaration.

NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are components of energy metabolism pathways (Pfannhauser Declaration, para. 5). NADH and $FADH_2$ are the major electron carriers in the oxidation of fuel molecules (Pfannhauser Declaration, para. 10). FAD may be fully reduced to $FADH_2$ or half-reduced to FADH (Pfannhauser Declaration, para. 10). NADPH is the major electron donor in reductive biosynthesis (Pfannhauser Declaration, para. 10). FMN is a component of Complex I of the mitochondrial electron transport chain

(Pfannhauser Declaration, para. 10). $FMNH_2$ is the reduced form of FMN and FMNH is the radical form of FMN (Pfannhauser Declaration, para. 10).

As stated in the Pfannhauser Declaration, energy metabolism pathways are learned by university students in their entry-level biochemistry courses (Pfannhauser Declaration, para. 5). Thus, even first-year university students who have taken an entry-level biochemistry course would readily understand the meaning of the terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH.

The Pfannhauser Declaration further notes that is clear from the present specification that NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are described in the context of energy metabolism and electron transfer (Pfannhauser Declaration, para. 10). The Pfannhauser Declaration concludes that in view of the description of NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH in the present specification and the common use of these well-known terms in the biochemistry field, there is no question that scientists (and even students) in this field would readily understand the meaning of NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH as recited in the present claims and specification. (Pfannhauser Declaration, para. 11).

3. The Examiner Has Not Met His Burden

In rejecting a claim under the written description requirement, the Examiner has the initial burden of presenting evidence or reasons why a person skilled in the art would not recognize in an Applicant's disclosure a description of the invention defined in the claims. *In re Wertheim*, 541 F.2d 257, 262 (CCPA 1976). Accordingly, the Examiner is required: (1) to set forth the claim limitation not described; and (2) to provide reasons why a person skilled in the art would not have recognized the description of the limitation in view of the disclosure of the application as filed. *Interim Guidelines for the Examination of Patent Applications Under 35*

U.S.C. 112, Paragraph 1. In making an indefiniteness rejection, the Examiner is required to provide an analysis as to why the claim is "vague and indefinite." MPEP § 2173.02.

The only alleged reasoning provided to support the written description and definiteness rejections is that the abbreviations render the claims "totally unsearchable" because a person of ordinary skill in the art "would have no idea what one is searching and looking for." (Action, p. 3; *see also* p. 4). It is unclear why the Examiner considers the terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH "totally unsearchable." To demonstrate that these terms are in fact searchable, Applicant typed the search term "NADH" into the PubMed database on September 11, 2006. The search returned 39,521 articles. To obtain a more manageable number of results, the search was then limited to only those articles published in 2002 and in which "NADH" occurred in the title. With these limitations the search returned 124 articles. A copy of the search results is attached as Appendix B. Numerous results were also obtained when Applicant searched the PubMed database for any of the terms NADPH, $FADH_2$, $FMNH_2$, FADH, or FMNH. The Action's unsupported assertion that the claims are "totally unsearchable" is clearly inaccurate. Thus, the Action did not meet its burden of establishing that the claims do not satisfy the definiteness and written description requirements.

4. Conclusion

For the reasons set forth above, the present claims are definite and supported by adequate written description. Applicant, therefore, requests the withdrawal of these rejections.

D. Claim Objections

Claim 10 is objected to under 37 C.F.R. § 1.75(c) as being of improper dependent form for failing to further limit the subject matter of a previous claim. Applicant traverses this objection.

An antioxidant is a compound that inhibits oxidation by binding free oxygen radicals. As recited in claim 9, antioxidant A is NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, or FMNH; and antioxidant B is chlorophyll and/or a reduced ferredoxin. An "oxygen-sequestering substance" is a substance, such as an oil, that reduces, or largely prevents, any contact between antioxidant A and oxygen (Specification, p. 6, ln. 1-22). As described in the specification, an "oxygen-sequestering substance" protects antioxidant A by preventing the ***contact*** of antioxidant A with oxygen, whereas another antioxidant (i.e., antioxidant C) protects antioxidant A by ***reducing oxygen*** before the oxygen can react with antioxidant A (p. 6, ln. 23-32). Thus, claim 10 is a proper dependent claim because it references claim 9 and specifies a further limitation, namely that the composition of claim 9 further comprise an oxygen-sequestering substance, which is not the same substance as antioxidant A or antioxidant B as defined in current claim 9.

E. Conclusion

Applicant believes this to be a complete reply to the Office Action dated June 21, 2006, and respectfully requests favorable consideration of the claims in view of the amendments and statements contained herein.

The Examiner is invited to contact the undersigned attorney with any questions, comments or suggestions relating to the referenced patent application.

Respectfully submitted,

Travis M. Wohlers
Reg. No. 57,423
Attorney for Applicant

(Customer No. 32425)
FULBRIGHT & JAWORSKI L.L.P.
600 Congress Avenue, Suite 2400
Austin, Texas 78701
512.536.5654 (voice)
512.536.4598 (fax)

Date: September 15, 2006

APPENDIX A

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Behzad SADEGHI *et al.*	Group Art Unit: 1714
Serial No.: 10/535,330	Examiner: Anthony, Joseph David
Filed: May 18, 2005	Atty. Dkt. No.: SONN:073US
For: NADH/NADPH-CONTAINING COMPOUND	

DECLARATION OF WERNER PFANNHAUSER, Ph.D.

I, Werner Pfannhauser, hereby declare as follows:

1. I am an Austrian citizen residing at Kreuzgasse 79, A - 1180 Vienna, Austria.

2. I am currently the head of the Institute of Food Chemistry and Technology at the Technical University of Graz in Graz, Austria. I have extensive experience in the fields of chemistry and biochemistry. A copy of my *Curriculum Vitae* is attached as Exhibit A.

3. I have reviewed the specification of the above-reference application, the currently pending claims, the amended set of claims, and the Office Action dated June 21, 2006.

4. I understand that the Examiner rejected claims 9-18 as being indefinite and lacking adequate written description. I understand that the Examiner asserts that because the specification does not define the chemical names for the abbreviations NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH, a person of ordinary skill in the art would not understand the meaning of these terms. I do not find this to be the case.

5. The terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are well-known in the field of biochemistry as they are components of energy metabolism pathways. In my experience, both as a student and as a professor, energy metabolism pathways (*e.g.*, glycolysis, citric acid cycle, and oxidative phosphorylation) are taught to university students in their entry-level biochemistry courses. As evidence of this, I have attached as Exhibits B-G pages from two general biochemistry text books: Voet & Voet, BIOCHEMISTRY, 2d Ed., (John Wiley & Sons, Inc., 1995) and Streyer, BIOCHEMISTRY, 3d Ed. (W.H. Freeman and Co., 1988).

6. Exhibit B is a table entitled "Some Common Biochemical Abbreviations" from Voet & Voet, which shows that NADH, NADPH, $FADH_2$, FADH, and FMN are well-known abbreviations in biochemistry. Exhibit C contains pages from the index of Voet and Voet listing NADH, NADPH, $FADH_2$, FADH, and FMN. Although the reduced and radical forms of FMN are not listed in the index, $FMNH_2$ and FMNH are described in Voet & Voet at, for example, page 575 (Exhibit D). Exhibit E is a table from the Streyer text book entitled "Common Abbreviations in Biochemistry," which lists NADH, NADPH, $FADH_2$, $FMNH_2$, FAD, and FMN.

7. Exhibit F contains pages 785 to 788 from Voet & Voet and provides a summary of the major energy metabolism pathways. NADH, NADPH, and $FADH_2$ are specifically mentioned on these pages. I also note that they are referred to as "NADH," "NADPH," and "$FADH_2$" and not as "nicotinamide adenine dinucleotide, reduced form," "nicotinamide adenine dinucleotide phosphate, reduced form," and "flavin adenine dinucleotide, reduced form." FADH is described on pages 400-401 of Voet & Voet (Exhibit G). $FMNH_2$ and FMNH are described on page 575 of Voet & Voet (Exhibit D).

8. Accordingly, anyone who has taken an entry-level biochemistry course would readily understand the meaning of the terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH. Of course, scientists who conduct research in this field would also readily understand the meaning of these terms.

9. Although the compounds NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH may also be referred to as nicotinamide adenine dinucleotide, reduced form; nicotinamide adenine dinucleotide phosphate, reduced form; flavin adenine dinucleotide, reduced form; flavin mononucleotide, reduced form; flavin adenine dinucleotide, radical form; and flavin mononucleotide, radical for; respectively; it is has been my experience from the scientific literature and from communications with my colleagues and students that NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are the more commonly used terms. The preferred use of the terms NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH is evident in Voet & Voet. For example, if a person looks up "nicotinamide adenine dinucleotide, reduced form" in the index of Voet & Voet (attached as Exhibit D) that person would be directed to "*see* NADH." The same is true of NADPH, $FADH_2$, FADH, and FMN.

10. From my review of the present specification, it is clear that NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are described in the context of energy metabolism and electron transfer. As explained in the preceding paragraphs, it is well-known that NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH are components of energy metabolism pathways (*see also* Exhibits B-G). In particular, it is well-known that NADH and $FADH_2$ are the major electron carriers in the oxidation of fuel molecules, and that FAD may be fully reduced to $FADH_2$ or half-reduced to FADH. NADPH is the major electron donor in reductive biosynthesis. FMN is a

component of Complex I of the mitochondrial electron transport chain and $FMNH_2$ is the reduced form of FMN and FMNH is the radical form of FMN.

11. In view of the description of NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH in the present specification and the common use of these well-known terms in the biochemistry field, there is no question that scientists (and even students) in this field would readily understand the meaning of NADH, NADPH, $FADH_2$, $FMNH_2$, FADH, and FMNH as recited in the present claims and specification.

12. I declare that all statements made of my knowledge are true and all statements made on the information are believed to be true; and, further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under § 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of this application or any patent issued thereupon.

Date: 13.9.2006

Werner Pfannhauser, Ph.D.

EXHIBIT A

O.Univ.Prof. Dr. Werner Pfannhauser
Institute of Food Chemistry and –technology, University of Technology Graz
A- 8010 Graz, Petersgasse 12/2
Private : A - 8081 Heiligenkreuz am Waasen
A - 1180 Wien, Kreuzgasse 79

CURRICULUM

7.6.1940	born in Vienna / Austria
2.6.1959	Matura BG XVIII Vienna
1.9.1963 - 31.8.1965	Employee (research contract) at Wienerberger Ziegelfabriks- und Baugesellschaft, Vienna, working at TGM (Higher technical School)
1.9.1963 - 31.8.1969	Assistsant at TGM (Higher Technical School), Department of Silica Techniques
1969	Grant for gifted students
1969 - 1971	Thesis at Institute of Analytical Chemistry (Univ.Prof. F. Hecht) University of Vienna
8.7.1971	Promotion
24.1.1971	Titel Engeneer (Ing)
16.8.1971 - 31.8.1993	Chemist, Senior Scientist (1974) and Vizedirector (1981) of Forschungsinstitut der Ernährungswirtschaft (Research Institute of the Food Industry), Vienna
1978	Research Grant of the City of Vienna
1979 - 1996	Secretary of the Federation of European Chemical Societies (FECS) Working Party of Food Chemistry (WPFC), now renamed Division of Food Chemistry
since 1994	Austrian Delegate in FECS / FCD
since 1984	Board Member of the Austrian Society of Analytical Chemistry (ASAC),
since 1991	Vice President of ASAC
7.12.1988	Habilitation for Analytical Chemistry ar Technical University of Vienna
since 1992	Chairman of the Working Party of Food Chemistry of the Austrian Chemical Society (GÖCh)
1.10.1993	Appointed as a Full Professor of Food Chemistry at the Technical University of Graz, Institute of Bio- and Food Chemistry
1995 - 1998	Scientific director of Lebensmittelversuchsanstalt and Forschungsinsitut der Ernährungswirtschaft, Vienna
September 1996	Editor of Ernährung / nutrition
1996 –2000	President of the Austrian Society of Nutrition (ÖGE)
11/2000	Head of the newly founded Institute of Food Chemistry and -technology

Private:
married with Dkfm. Gertraud Pfannhauser, born Gruber, 5 sons;
Owner of a private consulting agency in Vienna

Distinctions:
1988 : Gold Medal of the Italian Society of Flavour Research (Societa Scienze Aromatizzanti SSA)
1994 : Silver Medal of Merit of The City of Vienna

PUBLIKATIONSLISTE

O. Univ. Prof. Dr. Werner Pfannhauser

Institut für Lebensmittelchemie und -technologie
TU-Graz
8010 Graz, Petersgasse 12/II

1991

W.Pfannhauser
Die Schwermetallbelastung der österreichischen Nahrung im internationalen Vergleich
Ernährungsforschung 36, 13, (1991)

W.Pfannhauser
Spurenelemente in der Nahrung
Österreichische Apotheker Zeitung 45, (13) 269 (1991)

1992

W. Pfannhauser
Das essentielle Spurenelement Selen : Bedeutung, Wirkung und Vorkommen in der Nahrung. I. Essentialität, Funktion und Aufnahme. Selengehalte in Böden, Pflanzen und Tieren.
Ernährung / nutrition 16, (9), 506 (1992)

Das essentielle Spurenelement Selen : Bedeutung, Wirkung und Vorkommen in der Nahrung. II. Selen und die Immunlage des Organismus
Ernährung / nutrition 16, (10) 567 (1992)

Das essentielle Spurenelement Selen : Bedeutung, Wirkung und Vorkommen in der Nahrung. III. Selenversorgung und Aufnahmedaten aus Österreich im Vergleich mit Daten aus anderen Ländern. Schlußfolgerungen.
Ernährung / nutrition 16, (11) 642 (1992)

1993

W.Pfannhauser
Volatiles formed during Extrusion Cooking of Cereals
Flavour and Frangrance Journal 8, 109, (1993)

W.Pfannhauser
Selenaufnahme in Europa
Proceedings „Defizit und Überschuß an Mengen- und Spurenelementen in der Ernährung. S 79 -94
Jena 1994

1994

W.Pfannhauser
Versorgungsstatus mit dem essentiellen Spurenelement Selen in Österreich
Lebensmittelchemie 48, 123 (1994)

G. Cvirn, M. Murkovic, W. Pfannhauser
Zearalenon und Deoxynivalenol in österreichischem Getreide
Mitt. Hygiene (Bern) 85, 728 (1994)

H.Löw, M. Murkovic, W. Pfannhauser
Bestimmung von 2-Amino-3-methylimidazol[4,5-f]quinoilin (IQ) in Fleischprodukten
Proceedings Österreichische Chemietage 1994 Graz

Strigl A.W., Leitner E. u. Pfannhauser W.
Vorkommen und Analyse der Farbstoffe der Schwarzen Apfelbeere (Aronia melanocarpa)
8. Österreichische Chemikertage Graz, Proceedings, S. 97. (1994)

1995

W.Pfannhauser
Der Versorgungsstatus mit dem essentiellen Spurenelement Selen in Österreich
Lebensmittel- und Biotechnologie 1995, 17

A.W.Strigl, E.Leitner, W.Pfannhauser
Zur Bestimmung des „Farbwertes" von Früchten und Beeren am Beispiel der Schwarzen Apfelbeere (Aronia melanocarpa)
Lebensmittelchemie 49, 03 (1995)

M. Wilplinger, I. Schönsleben, W. Pfannhauser
Chrom in österreichischen Lebensmitteln
Z. Lebensm. Unters. Forsch 201, 521 - 523 (1995)

A.W. Strigl, E. Leitner, W. Pfannhauser
Qualitative und Quantitative Analyse der Anthocyane in Schwarzer Apfelbeere (Aronia melanocarpa Michx.Ell.) mittels TLC, HPLC und UV/VIS - Spekrometrie
Z. Lebensm. Unters. Forsch. 201,266 (1995)

A.W. Strigl, E. Leitner, W. Pfannhauser
Die Schwarze Apfelbeere als natürliche Farbstoffquelle
Deut. Lebensm. Rdsch. 91, 177 (1995)

U.Pechanek, W.Pfannhauser, C. Holler, K.Irsigler, H.Pinscher
Chemical and physiological aspects of enzyme-modified fibre
Europ.J.Clin.Nutr. 49, Suppl. 3, 291 - 95 (1995)

Fuchs, A. Krämer-Schafhalter, S. Silhar, M. Kovac, W. Pfannhauser
Influence of particle size and solvents on anthocyanin extraction of black chokeberry (Aronia melanocarpa)
Current Status and Future Trends in Analytical Food Chemistry
Proceedings of EURO FOOD CHEM VIII, Vienna, 1995, p.227
G.Sontag, W.Pfannhauser eds.; ISBN 3-900554-17-X

Fuchs, A. Krämer-Schafhalter, S. Silhar, M. Kovac, W. Pfannhauser
Reinigung von Anthocyanen aus der Schwarzen Apfelbeere (Aronia melanocarpa Nero) über Festphasen
13. HP-Forum Analytik, Wien, 22.-24.1.1996 (Poster)

Krämer-Schafhalter, H. Fuchs, A. Strigl, S. Silhar, M. Kovac, W. Pfannhauser
Process Consideration for Anthocyanin Extraction from Black Chokeberry (Aronia melanocarpa Ell.)
Presentation at the International Symposium on Natural Colorants, Acapulco, Mexico, 23.-27.1.1996

Strigl, A. Krämer-Schafhalter, H. Fuchs, M. Scharf, E. Leitner, W. Pfannhauser
Extraction and Analysis of the Anthocyans in Black Chokeberry a(Aronia melanocarpa MICHX. ELL.)
Proceedings of the 2nd Internationl Symposium on Natural Colorants, Acapulco, Mexico, 1996

Krämer-Schafhalter, H. Fuchs, S. Silhar, M. Mariassyova, A. Kintlerova, M. Kovac und W. Pfannhauser
Gewinnung von Destillaten aus der schwarzen Apfelbeere (Aronia melanocarpa), Krasny Prcimysl, in prep.

1996

Fuchs, A. Kraemer-Schafhalter, S. Silhar, M. Mariassyova, A. Kintlerova, M. Kovac, W. Pfannhauser
Quality of dye from Aronia melanocarpa var. Nero and optimal extraction conditions, Bulletin PV (Bratislava), 35, 101-110 (1996)

M. Wilplinger, I. Schönsleben, W.Pfannhauser
Versorgungszustand der Österreicher mit dem Spurenelement Chrom
Z. Lebensm. Unters. Forsch 203, 207 - 209 (1996)

S. Schlemitz, W.Pfannhauser
Bestimmung von nitrierten polyzyklischen aromatischen Kohlenwasserstoffen in Lebensmitteln mittels gaschromatographischer Analyse.
(Poster beim Deutschen Lebensmittelchemiker Tag 1995)
Lebensmittelchemie 50, 21 (1996)

M.Murkovic, A.Hillebrand J.Winkler, W.Pfannhauser
Variability of vitamin E content in pumpkin seeds (Cucurbita pepo L.)
Z.Lebensm.Unters.Forsch 202, 275 - 78 (1996)

S.Schlemitz, W.Pfannhauser
Monitoring of nitropolycyclic aromatic hydrocarbons in food using gas chromatography
Z.Lebensm.Unters.Forsch. 203, 61-64 (1996)

B.Siegmund, E.Leitner, H.Siegl, I.Mayer, W.Pfannhauser
Die Kombination instrumenteller und sensorischer Methoden zur Identifizierung aromaaktiver Verbindungen in Fleisch
Mitt.Hygiene (Bern) 87, 296 - 306 (1996)

B.Siegmund, E.Leitner, I.Mayer, P.Farkas, J. Sadecka, W.Pfannhauser
Untersuchungen zur Problematik der Extraktion von Aromastoffen mit der simultanen Destillation-Extraktion nach Lickens-Nickerson
Deut. Lebensm. Rdsch. 92, 286 (1996)

H.Fuchs, A. Krämer-Schafhalter, W.Pfannhauser, S. Silhar, M.Mariassiva, A.Kintlerova, M.Kovac
Pigment from Aronia melanocarpa var. Nero and optimum extraction conditions
Bull. Potravin. Vysk. 35, 101 (1996)

S.Schlemitz, W.Pfannhauser
Analysis of nitro-PAHs in food matrices by on-line reduction and high performance liquid chromatography
Food Additives and Contaminants 13, 969 - 977 (1996)

B.Siegmund, E.Leitner, I.Mayer, P.Farkas, J.Sadecka, W.Pfannhauser, M.Kovac
Untersuchungen zur Problematik der Extraktion von Aromastoffen mir der simultanen Destillation-Extraktion nach Likens-Nickerson
Deutsche-Lebensmittel-Rundschau, (1996), 92(9), 286-290.

S. Schlemitz, W. Pfannhauser
Analysis of nitro-PAHs in food matrices by on-line reduction and high performance liquid chromatography
Food Additives and Contaminants, 8, 969-977, (1996)

Hillebrand, A., Murkovic, M., Winkler, J., und Pfannhauser, W.
Ein hoher Gehalt an Vitamin E und ungesättigten Fettsäuren als neues Zuchtziel des Kürbiszüchters
Ernährung/Nutrition 20(10):525-527, 1996.

R. van Eckert, P. Rait, W.
S. Pfannhauser
Österreichische Datenbank für überempfindliche Personen
Ernährung/ Nutrition (1996) 20(9):472-473

Response of different gliadin preparations in commercial ELISA-Kits
R. van Eckert, U. Swaton, W. Pfannhauser
11th Meeting of the Working Group on Prolamin Analysis and Toxicity,
6.11.-8.11.1996, Tecklenburg, Deutschland (Poster)

Österreichische Datenbank für überempfindliche Personen
R. van Eckert, R. Rait ,W. Pfannhauser
Internationaler Lebensmittelchemikertag, 12.9.1996, Freiburg im Breisgau, Deutschland (Poster)

Österreichische Datenbank für überempfindliche Personen
R. van Eckert, P. Rait, W. Pfannhauser
Österreichische Lebensmittelchemiker Tage, 12.9.-13.9.1996, Graz (Poster)

Anthocyanins of *Aronia melanocarpa*: analysis, stability, changes during treatment and storage
A. Krämer-Schafhalter, H. Fuchs, W. Pfannhauser, S. Šilhar, M. Máriássyová, A. Kintlerová, M. Kovác
Proceedings Symposium on Polyphenols and Anthocyanins as Food Colourants and Antioxidants, 15.11.1996, Wien (Poster)

The evaluation of the *Likens-Nickerson*-Extraction for the generation of aroma-extracts demonstrated at a convenient hen-broth, olfaction and electronic nose
B. Siegmund., E. Leitner, I. Mayer, W. Pfannhauser, P. Farkáš, J. Sádecká J., M. Kovác
3.11.-6.11.1996, Miami, USA (Poster)

Lebensmittelqualität - was ist das ?
W.Pfannhauser
Ernährung / nutrition 95, (1) 1 - 8 (1996)

1997

M.Murkovic, D. Wiltschko, W. Pfannhauser
Formation of α-Tocopherolquinone and α-Tocopherolquinone Epoxides in Plant Oil
Fett / Lipide 99, (5), 165 - 169 (1997)

B.Siegmund, E.Leitner, I.Mayer, W.Pfannhauser, P.Farkas, J. Sadecka,M.Kovac
5,6-Dihydro-2,4,6-trimethyl-4*H*-1,3,5- dithiazine - an aroma-active compound formed in course of the Likens-Nickerson extraction
Z.Lebensm. Unters.Forsch 205, 73 - 75 (1997)

M. Murkovic, M. Gailhofer, W. Steiner, W. Pfannhauser
Formation of zearalenone on wheat contaminated with Fusarium graminearum under controlled conditions
Z Lebensm Unters Forsch A 204 :39-42 (1997)

M. Wilplinger, W. Pfannhauser
Aktueller Versorgungszustand der Österreicher mit dem Spurenelement Chrom
Ernährung/Nutrition 21 (2) , 61-62 (1997)

M. Murkovic, M. Friedrich, W. Pfannhauser
Heterocyclic aromatic amines in fried poultry meat
Z Lebensm Unters Forsch A 205 347-350 (1997)

S. Schlemitz, W. Pfannhauser
Supercritical fluid extraction of mononitrated polycyclic aromatic hydrocarbons from tea - Correlation with the PAH concentration
Z Lebensm Unters Forsch A (1997) [in press]

Krämer-Schafhalter, H. Fuchs, A.W. Strigl, W. Pfannhauser
Die schwarze Apfelbeere zur Gewinnung von Naturfarbstoffen
Ernährung/Nutrition, 21 (6), 260-262 (1997)

M. Murkovic, S. Draxl, W. Pfannhauser
Vitamin B1 in österreichischem Getreide
Ernährung/Nutrition, 21 (6), 263 265 (1997),

P.Farkaš, J.Sádecká, M.Kovác, B.Siegmund, E.Leitner, W.Pfannhauser
Key Odourants of Pressure-Cooked Hen Meat
Food Chemistry, 60,(4), 617 - 621 (1997)

R. van Eckert, P. Rait, W. Pfannhauser
Österreichische Datenbank für überempfindliche Personen
Lebensmittelchemie 51, (6) (1997)

Bildung von heterozyklischen aromatischen Aminen in gebratenem Putenfleisch
M. Murkovic, M. Friedrich, W. Pfannhauser
HP-Forum Analytik, 21.1.-23.1.1997, Wien (Poster)

Vitamin B1 in österreichischem Getreide
M. Murkovic, S. Draxl, W. Pfannhauser
HP-Forum Analytik, 21.1.-23.1.1997, Wien (Poster)

Can erucic acid be used as an indicator for adulteration of pumpkin seed oil with rape seed oil?
M. Murkovic, S. Draxl, J. Winkler, W. Pfannhauser
EURO FOOD CHEM IX, 24.9.-26.9.1997, Interlaken, Schweiz (Poster)

Bildung von 2-Amino-1-methyl-6-phenylimidazo[4,5-b]pyridin (PhIP) einem Kanzerogen aus gebratenem Fleisch in Modellreaktionen
S. Geiszler, M. Murkovic, W. Pfannhauser
Österreichische Lebensmittelchemiker Tage, 12.9.-13.9.1997, Graz (Poster)

Oxidationsprodukte von a-Tocopherol in Speiseöl
D. Wiltschko, M. Murkovic, W. Pfannhauser
Österreichische Lebensmittelchemiker Tage, 12.9.-13.9.1997, Graz (Poster)

Tocopherolchinon als Abbauprodukt von Vitamin E in Milch
C. Eixelsberger, M. Murkovic, W. Pfannhauser
Österreichische Lebensmittelchemiker Tage, 12.9.-13.9.1997, Graz (Poster)

Vitamin B1 in österreichischem Getreide
M. Murkovic, S. Draxl, W. Pfannhauser
2. Seggauer Analysentage, 19.6.-20.6.1997, Seggau/Leibnitz (Poster)

Heterocyclic aromatic amines in fried poultry meat

M. Murkovic, M. Friedrich, W. Pfannhauser
4th Symposium on Instrumental Analysis, 20.5-23.5.1997, Graz (Poster)

Bildung von heterozyklischen aromatischen Aminen in Modellsystemen
M. Murkovic, S. Geiszler, K. Fröhlich, W. Pfannhauser
GDCh-Hauptversammlung und 100-Jahrfeier der GÖCH, 7.9.-11.9.1997, Wien (Poster)

Chromium content in Austrian diets
M. Wilplinger, W. Pfannhauser
FAO-Meeting, 3./4.4.1997, Budapest (Poster)

Chromium supply in Austria
Wilplinger M., Pfannhauser W.
EURO FOOD CHEM IX, 24.9.-26.9.1997, Interlaken, Schweiz (Poster)

Determination of oxygenated compounds in spirits using a miniaturised plasma atomic emission detector
D. Platzer, E. Kahr, G. Knapp, E. Leitner, W. Pfannhauser
In Vino Analytica Scientia, 12.6.-14.6.1997, Bordeaux (Poster)

Determination of the sensorial properties of a convenient hen-broth
B. Siegmund, I. Mayer, E. Leitner, W. Pfannhauser, P. Farkaš, J. Sádecká, M. Kovác
5th Wartburg Aroma Symposium, 17.3.-20.3.1997, Eisenach, BRD (Poster)

The importance of a GC retention index database for flavour analysis demonstrated at the identification of aroma-active compounds of recooked dried hen meat
Farkaš P., Pfannhauser W., Sádecká J., Pet´ka, M. Kovác, B. Siegmund, E. Leitner
5th Wartburg Aroma Symposium, 17.3.-20.3.1997, Eisenach, BRD (Poster)

Qualität, Stabilität und Applikation von Anthocyanen aus der Schwarzen Apfelbeere (*Aronia melanocarpa* Nero)
H.Fuchs, A. Krämer-Schafhalter, S. Šilhar, M. Kovác, W. Pfannhauser
100-Jahrfeier GÖCH, 26. GDCH-Hauptversammlung, 7.9.-11.9.1997, Wien (Poster)

Characterisation of anthocyanin colorants from Chokeberry (*Aronia melanocarpa*) by determination of quality parameters
H. Fuchs, A. Krämer-Schafhalter, S. Šilhar, M. Kovác, W. Pfannhauser
Euro Food Chem IX, 24.9.-26.9.1997, Interlaken, Schweiz (Poster)

Nahrungsmittel (Europäische Datenbank) in "Allergologie für die Praxis 5, Mönchengladbach 1996"
R. van Eckert, W. Pfannhauser
Hrsg. W. Jorde, Dustri-Verlag Dr. Karl Feistle, Deisenhofen bei München, 1. Aufl. 1997 (Poster)

Determination of proteins with ELISA-Methods: Doubtful quantitative results?
R. van Eckert, W. Pfannhauser
Euro Food Chem IX, 24.9.-26.9.1997, Interlaken, Schweiz (Poster)

Kapillarelektrophoretische Trennung von Weizenprolaminen
R. van Eckert, H. Siegl, S. Zöchling, W. Pfannhauser

100-Jahrfeier GÖCH, 26. GDCH-Hauptversammlung, 7.9.-11.9.1997, Wien (Poster)

Antioxidantien und Gesundheit
W.Pfannhauser
Ernährung / nutrition 21, (11) 496 - 499 (1997)

Bestimmung des Fettgehaltes von Lebensmitteln durch Extraktion mit überkritischem Kohlendioxid
R.Melinz, S.Fister, W.Pfannhauser
Ernährung / nutrition 21, (12) 557 -561 (1997)

M. Wilplinger, W.Pfannhauser
Fragestellungen zur Magnesiumversorgung
Ernährung / nutrition 21, 321 – 23 (1997)

1998

Die elektronische Nase - eine neue Technik in der Lebensmittelsensorik
B. Siegmund, W. Pfannhauser
Ernährung/nutrition 22, 154-157 (1998)

Selengehalt in der Nahrung und dessen Zusammenhang zum Gehalt im Boden
M. Wilplinger, A. Sima, W.Pfannhauser
N. Lebensmittelchemie (1998) 52,93 – 95

M. Wilplinger. W. Pfannhauser
Chromium in Tea Leaves
Metal Ions in Biology and Medicin 5, 327 – 331 (1998)

M. Wilplinger. S. Zöchling, W. Pfannhauser
Chrom im Boden und in der Nahrung
VitaMinSpur (1998) 13, 117-120

M. Wilplinger, U. Schaller, W. Pfannhauser
Versorgung mit Nickel an verschiedenen Standorten in Österreich
Z.Lebensm. Unters. Forsch. (im Druck)

P.M. Abuja, M. Murkovic. W.Pfannhauser
Antioxidant and Prooxidant Activities of Elderberry (Sambucus nigra) Extract in Low-Density Lipoprotein Oxidation
J. Agric. Food Chem 1998, 46, 4091 – 96

A. Krämer-Schafhalter, H. Fuchs, W.Pfannhauser
B. Solid – Phase Extraction (SFE) – a comparison of 16 Materials for the Purification of Anthocyanins from Aronia melanocarpa var. Nero
J. Sci. Food Agric. 1998, 78, 435 - 440

M.Murkovic, D. Steinberger, W.Pfannhauser
Antioxidant spices reduce the formation of heterocyclic amines in fried meat
Z. Lebensm. Unters. Forsch. A 207, 477 – 480 (1998)

1999

M.Murkovic, H.-J. Weber, S. Geißler, K. Fröhlich, W.Pfannhauser
Formation of the food associated carcinogen 2-amino-1-methyl[4,5-b]pyridine (PhIP) in model systems
J.Food Chem 65, 233-237 (1999)

M. Wilplinger, S. Zöchling, W.Pfannhauser
An Analysis of the Manganese Suppy in Austria on the Basis of a Selected Diet
Z. Lebensm. Unters. Forsch. A (1999) 208: 251 – 53

T. Wald, R van Eckert, A. Sima, W.Pfannhauser
Untersuchung der Gliadinuntergruppen österreichischer Weizensorten
Getreide Mehl und Brot 53, 1 (1999)

R. van Eckert, T. Wald, A. Sima, F. Repnegg, W.Pfannhauser
Immunchemische Untersuchungen von chromatographisch getrennten Gliadin – Fraktionen
Lebensmittelchem. 53, 29 (1999)

B.Siegmund, W. Pfannhauser
Changes of the volatile fraction of cooked chicken meat during chill storage : results obtained by the eclectronic nose in comparison to GC – MS and GC olfactometry
Z. Lebensm. Unters. Forsch A (1999) 208; 336 – 341

B.Siegmund, E. Leitner, W.Pfannhauser
Development of a simple samle preparation technique for gas chromatographic-mass spectrometric determination of nicotine in edible nightshades (Solanaceae)
J. Chromatography A 840, (1999) 249 – 260

B.Siegmund, E.Leitner, W.Pfannhauser
Determination of the Nicotine Content of Various Edible Nightshades (Solanaceae) and Their Products and Estimation of the Associated Dietary Nicotine Intake
J.Agric. Food Chem. 1999, 47, 3113 – 3120

S. Porta, W.Temmel, T. Gifford, J.Rand, D.Westmoreland, A.Sima, W.Pfannhauser, H. Bacher
Human field experiments about the interrelationbsship of Magnesium, electrolyte and blood gas changes proportional to the intensity of accumulated workload – a diagnostic approach
Magnesium Bulletin (1999) 3, 61 – 69

E.Leitner, W.Pfannhauser
Identification of aroma active compounds in cardboard using solid phase microextraction (SME) coupled with GC-MS and GC-olfactometry
In Frontiers of Flavour Science, 2000
p- 74-78

2000

B. Siegmund. W.Pfannhauser
Chill starage of cooked chicken meat – changes in the volatile fraction observed by the electronic nose in comparison to GC-MS and GC-olfactrometry
In Frontiers of Flavour Science, 2000
p. 148 –152

G. Leitner, D. Westmoreland, M. Knapp, K. Spencer, J. Merback, V. Kruzik, M. Weger, W. Pfannhauser, S. Porta
Stress induced electrolyte and blood gas changes with and without a six days oral treatment with elderberry (Sambucus Nigra L.) concentrate
Magnesium Bull. 22,(3), 72-76 (2000)

M. Murkovic. W.Pfannhauser
Stability of pumpkin seed oil
Eur. J. Lipid Sci. Technol. 102, 607 – 611 (2000)

M.Murkovic, H. Toplak, U.Adam, W.Pfannhauser
Analysis of Anthocyanins in Plasma for Determination of their Bioavailability
J. Food Comp. Anal. 13, 291-96 (2000)

M.Murkovic, K.Gams, S.Draxl, W.Pfannhauser
Development of an Austrian Carotenoid Database
J.Food Comp. Anal. 13, 435-40 (2000)

A.Sima, M. Wilplinger, S. Zöchling, S. Heumann, U. Schaller, W. Pfannhauser
Trace Elements in Austrian Food
Trace Elements in Man and Animal Nutrition No 10
Ed. A.M. Roussel, R.A. Anderson, A.E. Favier
Kluwer Academic / Plenum Publishers, New York, Boston, Dordrecht, London, Moscow, 2000
p.239 – 241

W.Pfannhauser
Malnutrizione e micronutrienti : aspetti practici in Austria
Malnutrizione – una sfida del terzio millennio per la societa postindustriale – strategie di prevenzione e cura
Ed. L. Lucchin
Il Pensiero Scientifico Editore, Roma, 2000
p.255 – 263

Murkovic M, Toplak H, Adam U, Pfannhauser W :
Analysis of anthocyanins in serum for determination of their bioavailability Journal of Food Composition and Analysis, 13 (2000) 435-440 (2000)

Murkovic M, Adam U, Pfannhauser W :
Analysis of anthocyane glycosides in human serum Fresenius J Anal. Chem, Vol 366, pp 379-381 (2000)

Mülleder U, Murkovic M, Pfannhauser W :
Analysis of metabolites of cyanidinglucosides Czech J. Food Sci., 18 (2000) 189 (2000)

Murkovic M, Gams K, Draxl S, Pfannhauser W :
Development of an Austrian carotenoid database J. Food Comp. Analys. 13 (2000) 435-440 (2000)

2001
M. Murkovic, U. Mülleder, U.Adam, W.Pfannhauser
„Detection of anthocyanins from elderberry juice in human urine
J. Sci. Fd. Agric. 81: 934-37 (2001)

Simonova, W.Pfannhauser
Einfluß der Lagerbedingungen auf die Bildung biogener Amine in Fleisch, Fisch und Gemüse
Ernährung / nutrition 25: (6) 253-259 (2001)

Mülleder, U., Murkovic, M., Pfannhauser W. :
Metabolism of cyanidin glycosides of elderberry. 2001 Pfannhauser, W., Fenwick, G.r., Khokhar, S. Biologically-active Phytochemicals in Food: Analysis, Metabolism, Bioabailability and Function. Cambridge, RSC, (2001)

B.Siegmund, D. E. Leyden, E. Zikulnig, E. Leitner, M. Murkovic, W. Pfannhauser, H. Reif
The contribution of dietary nicotine and dietary cotinine to salivary cotinine levels as a nicotine biomarker
Food Chemistry 74 (2001), 259 – 265; (2001)

2002
Bandoniene D, Murkovic M, Pfannhauser W, Venskutonis PR, Gruzdiene D :
Detection and activity evaluation of radical scavenging compounds by using DPPG free radical and on-line HPLC-DPPH methods European Food Research and Technology, 214, 143-147 (2002)

Mülleder U, Murkovic M, Pfannhauser W :
Urinary excretion of cyanidin glycosides J. Biochem. Biophys Methods, 53, 61-66, 2002 (2002)

K. Riediger, W. Pfannhauser
Magnesium-, Calcium- und Kaliumversorgung bei österreichischen Grundwehrdienern
Ernährung/Nutrition, Vol 26/nr. 10 2002, 401 – 407, (2002)

C. Bandonienė, M. Murkovic, W. Pfannhauser, R.R. Venskutonis, d. Gruzdienė
Detection and activity evaluation of radical scavenging compounds by using DPPH free radical and on-line HPLC-DPPH methods
Eur Food Res Technol (2002) 214:143 – 147, (2002)

2003

B.Siegmund, R. Weiss, W. Pfannhauser
Sensitive method for the determination of nitrated polycyclic aromatic hydrocarbons in the human diet
Anal Bioanal chem. (2003) 375: 175-181

O. Bejaoui-Kefi, S. Sabbah, M. Murkovic, M. Dachraoui, W. Pfannhauser
Red wines anthocyanins analyses by HPLC using different detection modes
Ernährung/Nutrition, Vol 27/Nr. 5 2003, 197 – 207, (2003)

S. Siegmund, K. Derler, W. Pfannhauser
Chemical and senory effects of glass and laminated carton packages on fruit juice products – Still a controversial topic
Swiss Society of Food Science and Technology. Published by Elsevier Ltd., Lebensm.-Wiss. u.-Technol. 37 (2004) 481 – 488, (2004)

2004

P. Bejaoui Kefi, S. Ssbbah, M. Dachraoui and W. Pfannhauser
HPLC determination of free phenolic accids using electrochemical, UV and ESI-MS detection methods and their Application to Tunisian red wines
Ernährung/Nutrition Vol 28/Nr. 9 2004, 350 – 360, (2004)

T. Zierler, B. Siegmund, W. Pfannhauser
Determination of off-flavour compounds in apple juice caused by microorganisms using headspace solid phase microextraction-gas chromatography- mass spectrometry
Analytica Chimica Acta 520 (2004) 3-11

EXHIBIT B

DONALD VOET
University of Pennsylvania
JUDITH G. VOET
Swarthmore College

BIOCHEMISTRY

SECOND EDITION

JOHN WILEY & SONS, INC.
New York Chichester Brisbane
Toronto Singapore

Acquisitions Editor: *Nedah Rose*
Marketing Manager: *Catherine Faduska*
Designer: *Madelyn Lesure*
Manufacturing Manager: *Susan Stetzer*
Photo Researcher: *Hilary Newman*
Illustration Coordinator: *Edward Starr*
Illustrators: *J/B Woolsey Associates*
Production Management: *Pamela Kennedy Oborski and Suzanne Ingrao*
Cover and Part Opening Illustrations © *Irving Geis*
This book was set in 9.5/12 Times Roman by Progressive Information Technologies and printed and bound by Von Hoffman Press. The cover was printed by Lehigh Press Lithographers. Color separations by Lehigh Press Colortronics.

Cover Art: Two paintings of horse heart cytochrome *c* by Irving Geis in which the protein is illuminated by its single iron atom. On the front cover the hydrophilic side chains are drawn in green, and on the back cover the hydrophobic side chains are drawn in orange. The paintings are based on an X-ray structure by Richard Dickerson.

Recognizing the importance of preserving what has been written, it is a policy of John Wiley & Sons, Inc. to have books of enduring value published in the United States printed on acid-free paper, and we exert our best efforts to that end.

John Wiley & Sons, Inc., places great value on the environment and is actively involved in efforts to preserve it. Currently, paper of high enough quality to reproduce full-color art effectively contains a maximum of 10% recovered and recycled post-consumer fiber. Wherever possible, Wiley uses paper containing the maximum amount of recycled fibers. In addition, the paper in this book was manufactured by a mill whose forest management programs include sustained yield harvesting of its timberlands. Sustained yield harvesting principles ensure that the number of trees cut each year does not exceed the amount of new growth.

TOTAL 10% RECYCLED PAPER
ALL POST-CONSUMER WASTE

ISBN: 0-471-58651-X

Printed in the United States of America

10 9 8 7 6 5 4 3 2

Some Common Biochemical Abbreviations[a]

A	adenine
aa	amino acid
aaRS	amino-acyl tRNA synthetase
ACAT	acyl-CoA:cholesterol acyl transferase
ACh	acetylcholine
ACP	acyl carrier protein
ADA	adenosine deaminase
ADH	alcohol dehydrogenase
ADP	adenosine diphosphate
AIDS	acquired immunodeficiency syndrome
AMP	adenosine monophosphate
AMPK	AMP-dependent protein kinase
ALA	δ-aminolevulinic acid
ATCase	aspartate transcarbamoylase
ATP	adenosine triphosphate
BChl	bacteriochlorophyll
bp	base pair
BPG	D-2,3-bisphosphoglycerate
BPheo	bacteriopheophytin
BPTI	bovine pancreatic trypsin inhibitor
C	cytosine
CaM	calmodulin
cAMP	cyclic AMP
CAP	catabolite gene activating protein
cAPK	cAMP-dependent protein kinase
cDNA	complimentary DNA
CDP	cytidine diphosphate
CDR	complimentarity determining region
CE	capillary electrophoresis
Chl	chlorophyll
CM	carboxymethyl
CMP	cytidine monophosphate
CoA or CoASH	coenzyme A
CoQ	coenzyme Q (ubiquinone)
CTP	cytidine triphosphate
D	dalton
d	deoxy
dd	dideoxy
DEAE	diethylaminoethyl
DG	*sn*-1,2-diacylglycerol
DHAP	dihydroxyacetone phosphate
DHF	dihydrofolate
DHFR	dihydrofolate reductase
DMF	*N,N*-dimethylformamide
DMS	dimethyl sulfate
DNP	2,4-dinitrophenol
DNA	deoxyribonucleic acid
Dol	dolichol
L-DOPA	L-3,4-dihydroxyphenylalanine
EF	elongation factor
EGF	epidermal growth factor
EPR	electron paramagnetic resonance
ER	endoplasmic reticulum
FAD	flavin adenine dinucleotide, oxidized form
$FADH\cdot$	flavin adenine dinucleotide, radical form[a]
$FADH_2$	flavin adenine dinucleotide, reduced form
FBP	fructose-1,6-bisphosphate
FBPase	fructose-1,6-biphosphatase
Fd	ferredoxin
FH	familial hypercholesterolemia
fMet	*N*-formylmethionine
FMN	flavin mononucleotide
F1P	fructose-1-phosphate
F6P	fructose-6-phosphate
G	guanine
GABA	γ-aminobutyric acid
Gal	galactose
GalNAc	*N*-acetylgalactosamine
GAP	glyceraldehyde-3-phosphate
GAPDH	glyceraldehyde-3-phosphate dehydrogenase
GC	gas chromatography
GDP	guanosine diphosphate
Glc	glucose
GMP	guanosine monophosphate
G1P	glucose-1-phosphate
G6P	glucose-6-phosphate
GPI	glycosylphosphatidyl inositol
GSH	glutathione
GSSG	glutathione disulfide
GTP	guanosine triphosphate
HA	hemagglutinin
Hb	hemoglobin
HDL	high density lipoprotein
HGPRT	hypoxanthine–guanine phosphoribosyl transferase
HIV	human immunodeficiency virus
HMG-CoA	β-hydroxy-β-methylglutaryl-CoA
hnRNA	heterogeneous nuclear RNA
HPLC	high-performance liquid chromatography
hsp	heat shock protein
Hyl	5-hydroxylysine
Hyp	4-hydroxyproline
IDL	intermediate density lipoprotein
IF	initiation factor
IgG	immunoglobulin G
IHP	inositol hexaphosphate
IMP	inosine monophosphate
IP_1	inositol-1-phosphate
IP_3	inositol 1, 4, 5-triphosphate
IPTG	isopropylthiogalactoside
IR	infrared
IS	insertion sequence
ITP	inosine triphosphate
K_M	Michaelis constant
kb	kilo base pair

[a] The three-letter and one-letter abbreviations for the "standard" amino acid residues are given in Table 4-1.

kD	kilodaltons
KF	Klenow fragment
LCAT	lecithin:cholesterol acyl transferase
LDH	lactate dehydrogenase
LDL	low density lipoprotein
Man	mannose
Mb	myoglobin
MHC	major histocompatability complex
mRNA	messenger RNA
MS	mass spectrometry
NA	neuraminidase
NAD^+	nicotinamide adenine dinucleotide, oxidized form
NADH	nicotinamide adenine dinucleotide, reduced form
$NADP^+$	nicotinamide adenine dinucleotide phosphate, oxidized form
NADPH	nicotinamide adenine dinucleotide phosphate, reduced form
NAG	*N*-acetylglucosamine
NAM	*N*-acetylmuramic acid
NANA	*N*-acetylneuraminic (sialic) acid
NER	nucleotide excision repair
NMN	nicotinamide mononucleotide
NMR	nuclear magnetic resonance
NOESY	nuclear Overhauser effect spectroscopy
P or p	phosphate
P_i	orthophosphate ion
PAGE	polyacrylamide gel electrophoresis
PBG	porphobilinogen
PC	plastocyanin
PCR	polymerase chain reaction
PE	phosphatidyethanolamine
PEP	phosphoenolpyruvate
PEPCK	PEP carboxykinase
PFG	pulsed-field gel electrophoresis
PFK	phosphofructokinase
PG	prostaglandin
2PG	2-phosphoglycerate
3PG	3-phosphoglycerate
PDGF	platlet-derived growth factor
PGI	phosphoglucose isomerase
PGK	phosphoglycerate kinase
PGM	phosphoglycerate mutase
Pheo	pheophytin
PIP_2	phosphatidylinositol-4,5-bisphosphate
PK	pyruvate kinase
PKU	phenylketonuria
PLP	pyridoxal-5-phosphate
PNP	purine nucleotide phosphorylase
Pol	DNA polymerase
PP_i	pyrophosphate ion
PrP	prion protein
PRPP	5-phosphoribosyl-α-pyrophosphate
PS	photosystem
PSTV	potato spindle tuber virus
Q	ubiquinone (CoQ)
QH_2	ubiquinol
r	ribo
RER	rough endoplasmic reticulum
RF	release factor *or* replicative form
RFLP	restriction-fragment length polymorphism
RK	HMG-CoA reductase kinase
RNA	ribonucleic acid
RNAP	RNA polymerase
R5P	ribose-5-phosphate
RPC	reverse phase chromatography
rRNA	ribosomal RNA
RSV	Rous sarcoma virus
RT	reverse transcriptase
RTK	receptor tyrosine kinase
Ru1,5P	ribulose-1,5-bisphosphate
Ru5P	ribulose-5-phosphate
S	Svedberg unit
SAM	*S*-adenosylmethionine
SCID	severe combined immunodeficiency disease
SDS	sodium dodecyl sulfate
snRNA	small nuclear RNA
snRNP	small ribonuclear protein
S7P	sedoheptulose-7-phosphate
SRP	signal recognition particle
T	thymine
TBP	TATA box-binding protein
TBSV	tomato bushy stunt virus
TCA	tricarboxylic acid
THF	tetrahydrofolate
TIM	triose phosphate isomerase
TLC	thin layer chromatography
TMV	tobacco mosaic virus
TPP	thiamine pyrophosphate
tRNA	transfer RNA
TS	thymidylate synthase
TTP	thymidine triphosphate
U	uracil
UDP	uridine diphosphate
UDPG	UDP-glucose
UMP	uridine monophosphate
UTP	uridine triphosphate
UV	ultraviolet
V_{max}	maximal velocity
VLDL	very low density lipoprotein
XMP	xanthosine monophosphate
XP	xeroderma pigmentosum
Xu5P	xylulose-t-phosphate
YAC	yeast artificial chromosome
YADH	yeast alcohol dehydrogenase

EXHIBIT C

DONALD VOET
University of Pennsylvania

JUDITH G. VOET
Swarthmore College

BIOCHEMISTRY

SECOND EDITION

JOHN WILEY & SONS, INC.
New York Chichester Brisbane
Toronto Singapore

Acquisitions Editor: *Nedah Rose*
Marketing Manager: *Catherine Faduska*
Designer: *Madelyn Lesure*
Manufacturing Manager: *Susan Stetzer*
Photo Researcher: *Hilary Newman*
Illustration Coordinator: *Edward Starr*
Illustrators: *J/B Woolsey Associates*
Production Management: *Pamela Kennedy Oborski and Suzanne Ingrao*
Cover and Part Opening Illustrations © *Irving Geis*
This book was set in 9.5/12 Times Roman by Progressive Information Technologies and printed and bound by Von Hoffman Press. The cover was printed by Lehigh Press Lithographers. Color separations by Lehigh Press Colortronics.

Cover Art: Two paintings of horse heart cytochrome *c* by Irving Geis in which the protein is illuminated by its single iron atom. On the front cover the hydrophilic side chains are drawn in green, and on the back cover the hydrophobic side chains are drawn in orange. The paintings are based on an X-ray structure by Richard Dickerson.

Recognizing the importance of preserving what has been written, it is a policy of John Wiley & Sons, Inc. to have books of enduring value published in the United States printed on acid-free paper, and we exert our best efforts to that end.

John Wiley & Sons, Inc., places great value on the environment and is actively involved in efforts to preserve it. Currently, paper of high enough quality to reproduce full-color art effectively contains a maximum of 10% recovered and recycled post-consumer fiber. Wherever possible, Wiley uses paper containing the maximum amount of recycled fibers. In addition, the paper in this book was manufactured by a mill whose forest management programs include sustained yield harvesting of its timberlands. Sustained yield harvesting principles ensure that the number of trees cut each year does not exceed the amount of new growth.

TOTAL 10% RECYCLED PAPER
ALL POST-CONSUMER WASTE

ISBN: 0-471-58651-X

Printed in the United States of America

10 9 8 7 6 5 4 3 2

EXHIBIT D

DONALD VOET
University of Pennsylvania

JUDITH G. VOET
Swarthmore College

BIOCHEMISTRY

SECOND EDITION

JOHN WILEY & SONS, INC.
New York Chichester Brisbane
Toronto Singapore

Acquisitions Editor: *Nedah Rose*
Marketing Manager: *Catherine Faduska*
Designer: *Madelyn Lesure*
Manufacturing Manager: *Susan Stetzer*
Photo Researcher: *Hilary Newman*
Illustration Coordinator: *Edward Starr*
Illustrators: *J/B Woolsey Associates*
Production Management: *Pamela Kennedy Oborski and Suzanne Ingrao*
Cover and Part Opening Illustrations © *Irving Geis*
This book was set in 9.5/12 Times Roman by Progressive Information Technologies and printed and bound by Von Hoffman Press. The cover was printed by Lehigh Press Lithographers. Color separations by Lehigh Press Colortronics.

Cover Art: Two paintings of horse heart cytochrome *c* by Irving Geis in which the protein is illuminated by its single iron atom. On the front cover the hydrophilic side chains are drawn in green, and on the back cover the hydrophobic side chains are drawn in orange. The paintings are based on an X-ray structure by Richard Dickerson.

Recognizing the importance of preserving what has been written, it is a policy of John Wiley & Sons, Inc. to have books of enduring value published in the United States printed on acid-free paper, and we exert our best efforts to that end.

John Wiley & Sons, Inc., places great value on the environment and is actively involved in efforts to preserve it. Currently, paper of high enough quality to reproduce full-color art effectively contains a maximum of 10% recovered and recycled post-consumer fiber. Wherever possible, Wiley uses paper containing the maximum amount of recycled fibers. In addition, the paper in this book was manufactured by a mill whose forest management programs include sustained yield harvesting of its timberlands. Sustained yield harvesting principles ensure that the number of trees cut each year does not exceed the amount of new growth.

TOTAL 10% RECYCLED PAPER
ALL POST-CONSUMER WASTE

ISBN: 0-471-58651-X

Printed in the United States of America

10 9 8 7 6 5 4 3 2

O_2 consumes twice as many moles of NADH as of O_2, the P/O ratio for NADH reoxidation at Region 2 is 90 μmol of ADP/(2 × 15 μmol of O_2) = 3; that is, *3 mol of ADP are phosphorylated per mole of NADH oxidized.*

(b) The experiment is continued by inhibiting electron transfer from NADH by rotenone and adding an additional 90 μmol of ADP (Fig. 20-12; Region 4), this time together with an excess of the FAD-linked substrate succinate. Oxygen consumption again continues until all the ADP is phosphorylated, and the system again returns to the resting state (Fig. 20-12; Region 5). Calculation of the P/O ratio for $FADH_2$ oxidation yields the value 2; that is, *2 mol of ADP are phosphorylated per mole of $FADH_2$ oxidized.*

(c) In the same manner, *the oxidation of ascorbate/TMPD yields a P/O ratio of 1 (Fig. 20-12; Regions 6 and 7).*

These conclusions agree with the inhibitor studies indicating that there are three entry points for electrons into the electron-transport chain and with the standard reduction potential measurements exhibiting three potential jumps, each sufficient to provide the free energy for ATP synthesis (Fig. 20-8).

The P/O Ratios May Be Subject to Revision

Measurements of P/O ratios are subject to systematic experimental errors for which it is difficult to correct, such as inaccuracies in the measurement of the oxygen concentration, the presence of AMP, and proton leakage from mitochondria. Thus, the widely accepted P/O values of 3, 2, and 1 associated with NADH-, $FADH_2$-, and ascorbate/TMPD-linked oxidation may well be in error. Indeed, measurements by Peter Hinkle have yielded values close to 2.5, 1.5, and 1 for these quantities (we shall see in Section 20-3 that P/O ratios need not have integer values because the number of protons pumped out of the mitochondrion by any component of the electron transport chain may not be an integer multiple of the number of protons required to synthesize ATP from ADP + P_i). If these values are correct, then the number of ATPs that are synthesized per molecule of glucose oxidized is 2.5 ATP/NADH × 10 NADH/glucose + 1.5 ATP/$FADH_2$ × 2 $FADH_2$/glucose + 2 ATP/glucose from the citric acid cycle + 2 ATP/glucose from glycolysis = 32 ATP/glucose rather than the conventional value of 38 ATP/glucose implied by P/O ratios of 3, 2, and 1. However, since there is significant disagreement as to the validity of the revised P/O ratios, we shall, for the sake of consistency, use the more established values of 3, 2, and 1 throughout this textbook. You should nevertheless keep in mind that these values are disputed.

How the free energy of electron transport is actually coupled to ATP synthesis, a subject of active research, is discussed in Section 20-3. We first examine the structures of the four respiratory complexes in order to understand how they are related to the function of the electron-transport chain. Keep in mind, however, that as in most areas of biochemistry, this field is under intense investigation and much of the information we need for a complete understanding of these relationships has yet to be uncovered.

C. *Components of the Electron-Transport Chain*

Many of the proteins embedded in the inner mitochondrial membrane are organized into the four respiratory complexes of the electron-transport chain. Each complex consists of several protein components that are associated with a variety of redox-active prosthetic groups with successively increasing reduction potentials (Table 20-1). The complexes are all laterally mobile within the inner mitochondrial membrane; they do not appear to form any stable higher structures. Indeed, they are not present in equimolar ratios. In the following paragraphs, we examine their structures and the agents that transfer electrons between them. Their relationships are summarized in Fig. 20-13.

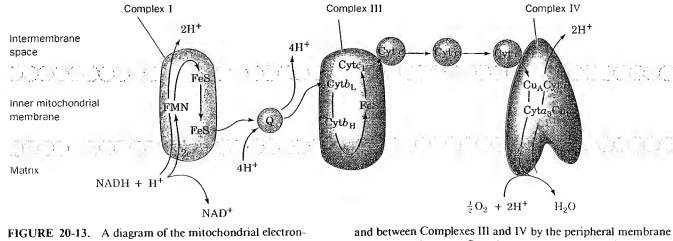


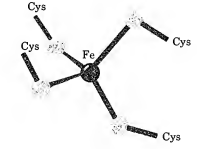
FIGURE 20-13. A diagram of the mitochondrial electron-transport chain indicating the pathway of electron transfer (*black*) and proton pumping (*red*). Electrons are transferred between Complexes I and III by the membrane-soluble CoQ and between Complexes III and IV by the peripheral membrane protein cytochrome *c*. Complex II (not shown) transfers electrons from succinate to CoQ.

1. Complex I (NADH–Coenzyme Q Reductase)

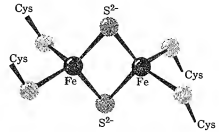
Complex I passes electrons from NADH to CoQ. This probably largest protein component of the inner mitochondrial membrane (850 kD) contains one molecule of **flavin mononucleotide (FMN;** a redox-active prosthetic group that differs from FAD only by the absence of the AMP group) and six to seven **iron–sulfur clusters** that participate in the electron-transport process (Table 20-1).

Iron–Sulfur Clusters Are Redox Active

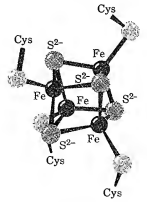
Three types of iron–sulfur clusters are known to occur as prosthetic groups of **iron–sulfur proteins (nonheme iron proteins):**



[Fe–S]



[2Fe–2S]



[4Fe–4S]

The two most common types, designated **[2Fe–2S]** and **[4Fe–4S] clusters,** consist of equal numbers of iron and sulfide ions and are both coordinated to four protein Cys sulfhydryl groups. One means of identifying these clusters utilizes the fact that their sulfide ions are acid labile: They are released as H_2S near pH 1. The **[Fe–S] cluster,** which has been found only in bacteria, consists of a single Fe atom liganded to four Cys residues. Note that the Fe atoms in all three types of clusters are each coordinated by four S atoms, which are more or less tetrahedrally disposed around the Fe. (A **[3Fe–4S] cluster,** which has been found in only one bacterial species, resembles a [4Fe–4S] cluster that lacks an Fe atom.) *The oxidized and reduced states of all iron–sulfur clusters differ by one formal charge regardless of their number of Fe atoms.* This is because the Fe atoms in each cluster form a conjugated system and thus can have oxidation states between the +2 and +3 values possible for individual Fe atoms. For example, each of the two [4Fe–4S] clusters in the protein **ferredoxin** (Fig. 20-14) contains one Fe(II) and three Fe(III)'s in its oxidized form and two Fe(II)'s and two Fe(III)'s in its reduced form. Iron–sulfur proteins also occur in the photosynthetic electron-transport chains of plants and bacteria (Section 22-2); indeed, photosynthetic electron-transport chains are thought to be the evolutionary precursors of oxidative electron-transport chains (Section 1-4C).

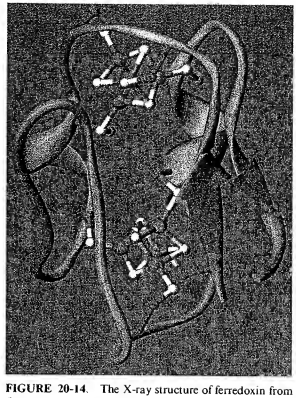


FIGURE 20-14. The X-ray structure of ferredoxin from *Peptococcus aerogenes,* a monomeric 54-residue protein that contains two [4Fe–4S] clusters. The C_β atoms of the four Cys residues liganding each [4Fe–4S] cluster are green, the Fe atoms are brown, and the S atoms are yellow. [Based on an X-ray structure by Elinor Adman, Larry Sieker, and Lyle Jensen, University of Washington.]

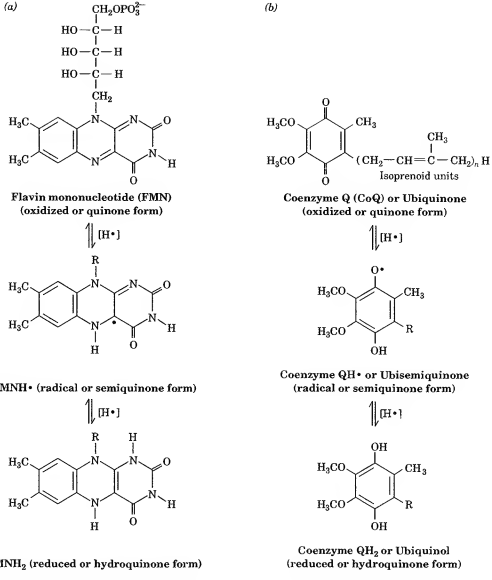


FIGURE 20-15. The oxidation states of (*a*) FMN and (*b*) CoQ. Both coenzymes form stable semiquinone free radical states.

The Coenzymes of Complex I

FMN and CoQ, the coenzymes of Complex I, can each adopt three oxidation states (Fig. 20-15). Although NADH can only participate in a two-electron transfer, both FMN and CoQ are capable of accepting and donating either one or two electrons because their semiquinone forms are stable. In contrast, the cytochromes of Complex III (see below), to which reduced CoQ passes its electrons, are only capable of one-electron reductions. *FMN and CoQ therefore provide an electron conduit between the two-electron donor NADH and the one-electron acceptors, the cytochromes.*

CoQ's hydrophobic tail makes it soluble in the inner mitochondrial membrane's lipid bilayer. In mammals, this tail consists of 10 C_5 isoprenoid units and hence the coenzyme is designated $\mathbf{Q_{10}}$. In other organisms, CoQ may have only 6 ($\mathbf{Q_6}$) or 8 ($\mathbf{Q_8}$) isoprenoid units.

2. Complex II (Succinate–Coenzyme Q Reductase)

Complex II, which contains the dimeric citric acid cycle enzyme succinate dehydrogenase (Section 19-3F) and three other small hydrophobic subunits, passes electrons from succinate to CoQ. It does so with the participation of a covalently bound FAD, one [4Fe–4S] cluster, two [2Fe–2S] clusters, and one cytochrome b_{560} (Table 20-1). We discuss the structures of the cytochromes in connection with that of Complex III below. [One of Complex II's iron–sulfur clusters has a standard reduction potential that is too negative (−0.245 V) to accept electrons from succinate; its function is unknown.]

EXHIBIT E

BIOCHEMISTRY

THIRD EDITION

LUBERT STRYER
STANFORD UNIVERSITY

W. H. FREEMAN AND COMPANY / NEW YORK

Library of Congress Cataloging-in-Publication Data

Stryer, Lubert.
Biochemistry.

Includes index.
1. Biochemistry. I. Title.
QP514.2.S66 1988 574.19'2 87-36486
ISBN 0-7167-1843-X
ISBN 0-7167-1920-7 (international student ed.)

Printed in the United States of America

2 3 4 5 6 7 8 9 0 RRD 6 5 4 3 2 1 0 8 9 8

COMMON ABBREVIATIONS IN BIOCHEMISTRY

A	adenine
ACP	acyl carrier protein
ADP	adenosine diphosphate
Ala	alanine
AMP	adenosine monophosphate
cAMP	cyclic AMP
cGMP	cyclic GMP
Arg	arginine
Asn	asparagine
Asp	aspartate
ATP	adenosine triphosphate
ATPase	adenosine triphosphatase
C	cytosine
CDP	cytidine diphosphate
CMP	cytidine monophosphate
CTP	cytidine triphosphate
CoA	coenzyme A
CoQ	coenzyme Q (ubiquinone)
cyclic AMP	adenosine 3′,5′-cyclic monophosphate
cyclic GMP	guanosine 3′,5′-cyclic monophosphate
Cys	cysteine
cyt	cytochrome
d	2′-deoxyribo
DNA	deoxyribonucleic acid
cDNA	complementary DNA
DNase	deoxyribonuclease
EcoRI	EcoRI restriction endonuclease
FAD	flavin adenine dinucleotide (oxidized form)
$FADH_2$	flavin adenine dinucleotide (reduced form)
fMET	formylmethionine
FMN	flavin mononucleotide (oxidized form)
$FMNH_2$	flavin mononucleotide (reduced form)
G	guanine
Gln	glutamine
Glu	glutamate
Gly	glycine
GDP	guanosine diphosphate
GMP	guanosine monophosphate
GSH	reduced glutathione
GSSG	oxidized glutathione
GTP	guanosine triphosphate
GTPase	guanosine triphosphatase
Hb	hemoglobin
HDL	high-density lipoprotein
HGPRT	hypoxanthine-guanine phosphoribosyl transferase
His	histidine
Hyp	hydroxyproline
IgG	immunoglobulin G
Ile	isoleucine
IP_3	inositol trisphosphate
ITP	inosine triphosphate
LDL	low-density lipoprotein
Leu	leucine
Lys	lysine
Met	methionine
NAD^+	nicotinamide adenine dinucleotide (oxidized form)
NADH	nicotinamide adenine dinucleotide (reduced form)
$NADP^+$	nicotinamide adenine dinucleotide phosphate (oxidized form)
NADPH	nicotinamide adenine dinucleotide phosphate (reduced form)
PFK	phosphofructokinase
Phe	phenylalanine
P_i	inorganic orthophosphate
PLP	pyridoxal phosphate
PP_i	inorganic pyrophosphate
Pro	proline
PRPP	phosphoribosylpyrophosphate
Q	ubiquinone (or plastoquinone)
QH_2	ubiquinol (or plastoquinol)
RNA	ribonucleic acid
mRNA	messenger RNA
rRNA	ribosomal RNA
scRNA	small cytoplasmic RNA
snRNA	small nuclear RNA
tRNA	transfer RNA
RNase	ribonuclease
Rubisco	ribulose 1,5-bisphosphate carboxylase
Ser	serine
T	thymine
Thr	threonine
TPP	thiamine pyrophosphate
Trp	tryptophan
TTP	thymidine triphosphate
Tyr	tyrosine
U	uracil
UDP	uridine diphosphate
UDP-galactose	uridine diphosphate galactose
UDP-glucose	uridine diphosphate glucose
UMP	uridine monophosphate
UTP	uridine triphosphate
Val	valine
VLDL	very low-density lipoprotein

EXHIBIT F

DONALD VOET
University of Pennsylvania

JUDITH G. VOET
Swarthmore College

BIOCHEMISTRY

SECOND EDITION

JOHN WILEY & SONS, INC.
New York Chichester Brisbane
Toronto Singapore

Acquisitions Editor: *Nedah Rose*
Marketing Manager: *Catherine Faduska*
Designer: *Madelyn Lesure*
Manufacturing Manager: *Susan Stetzer*
Photo Researcher: *Hilary Newman*
Illustration Coordinator: *Edward Starr*
Illustrators: *J/B Woolsey Associates*
Production Management: *Pamela Kennedy Oborski and Suzanne Ingrao*
Cover and Part Opening Illustrations © *Irving Geis*
This book was set in 9.5/12 Times Roman by Progressive Information Technologies and printed and bound by Von Hoffman Press. The cover was printed by Lehigh Press Lithographers. Color separations by Lehigh Press Colortronics.

Cover Art: Two paintings of horse heart cytochrome *c* by Irving Geis in which the protein is illuminated by its single iron atom. On the front cover the hydrophilic side chains are drawn in green, and on the back cover the hydrophobic side chains are drawn in orange. The paintings are based on an X-ray structure by Richard Dickerson.

Recognizing the importance of preserving what has been written, it is a policy of John Wiley & Sons, Inc. to have books of enduring value published in the United States printed on acid-free paper, and we exert our best efforts to that end.

John Wiley & Sons, Inc., places great value on the environment and is actively involved in efforts to preserve it. Currently, paper of high enough quality to reproduce full-color art effectively contains a maximum of 10% recovered and recycled post-consumer fiber. Wherever possible, Wiley uses paper containing the maximum amount of recycled fibers. In addition, the paper in this book was manufactured by a mill whose forest management programs include sustained yield harvesting of its timberlands. Sustained yield harvesting principles ensure that the number of trees cut each year does not exceed the amount of new growth.

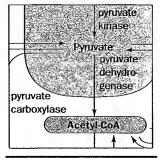
TOTAL 10% RECYCLED PAPER
ALL POST-CONSUMER WASTE

ISBN: 0-471-58651-X

Printed in the United States of America

10 9 8 7 6 5 4 3 2

CHAPTER



25

Energy Metabolism: Integration and Organ Specialization

At this point in our narrative we have studied all of the major pathways of energy metabolism. Consequently, we are now in a position to consider how organisms, mammals in particular, orchestrate the metabolic symphony to meet their energy needs. This chapter therefore begins with a recapitulation of the major metabolic pathways and their control systems, then considers how these processes are apportioned among the various organs of the body, and ends with a discussion of how the body deals with the metabolic challenge of starvation and how it responds to the loss of control resulting from diabetes mellitus.

1. MAJOR PATHWAYS AND STRATEGIES OF ENERGY METABOLISM: A SUMMARY

Figure 25-1 indicates the interrelationships among the major pathways involved in energy metabolism. Let us review these pathways and their control mechanisms.

1. Glycolysis (Chapter 16)

The metabolic degradation of glucose begins with its conversion to two molecules of pyruvate with the net generation of two molecules each of ATP and NADH. Under anaerobic conditions, pyruvate is converted to lactate (or, in yeast, to ethanol) so as to recycle the NADH. Under aerobic conditions, however, when glycolysis serves to prepare glucose for further oxidation, the NAD^+ is regenerated through oxidative phosphorylation (see below). The flow of metabolites through the glycolytic pathway is largely controlled by the activity of phosphofructokinase (PFK). This enzyme is activated by AMP and ADP, whose concentrations rise as the need for energy metabolism increases, and is inhibited by ATP and citrate, whose concentrations increase when the demand for energy metabolism has slackened. PFK is also activated by fructose-2,6-bisphosphate, whose concentration is regulated by the levels of glucagon, epinephrine, and norepinephrine through the intermediacy

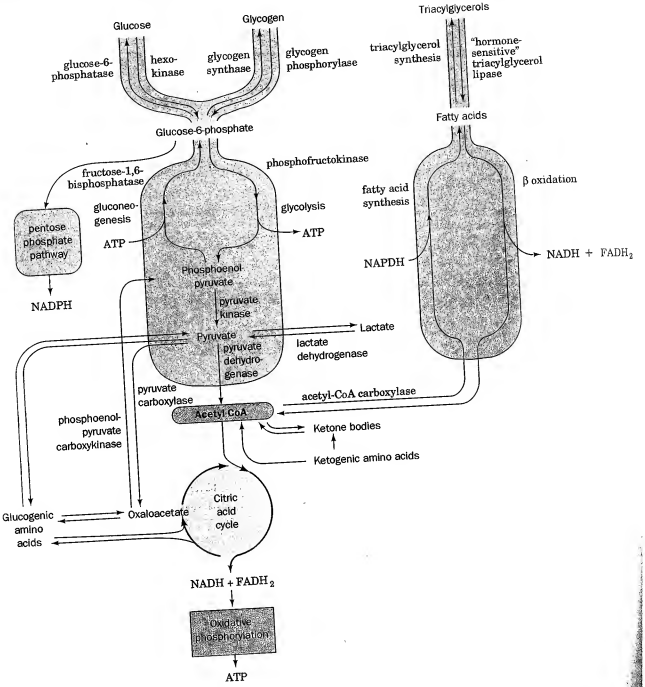


FIGURE 25-1. The major energy metabolism pathways.

of cAMP (Section 17-3F). Liver and heart muscle F2,6P levels are regulated oppositely: A [cAMP] increase causes an [F2,6P] decrease in liver and an [F2,6P] increase in heart muscle.

2. **Gluconeogenesis (Section 21-1)**
Mammals can synthesize glucose from a variety of precursors, including pyruvate, lactate, glycerol, and glucogenic amino acids, through pathways that occur mainly in liver and kidney. Many of these precursors are converted to oxaloacetate which, in turn, is converted to phosphoenolpyruvate and then, through a series of reactions that largely reverse the path of glycolysis, to glucose. The irreversible steps of glycolysis, those catalyzed by PFK and hexokinase, are bypassed in gluconeogenesis by hydrolytic reactions catalyzed, respectively, by fructose-1,6-bisphosphatase (FBPase) and glucose-6-phosphatase. FBPase and PFK may both be at least partially active simultaneously, creating a substrate cycle. This cycle, and the reciprocal regulation of PFK and FBPase, are important in regulating both the

direction of flux through glycolysis and gluconeogenesis (Sections 16-3 and 21-1B).

3. **Glycogen degradation and synthesis (Chapter 17)**
Glycogen, the storage form of glucose in animals, occurs mostly in liver and muscle. Its conversion to glucose-6-phosphate (G6P) for entry into glycolysis is catalyzed, in part, by glycogen phosphorylase, whereas the opposing synthetic pathway is mediated by glycogen synthase. These enzymes are reciprocally regulated through phosphorylation/dephosphorylation reactions as catalyzed by amplifying cascades that respond to the levels of the hormones glucagon and epinephrine through the intermediacy of cAMP.

4. **Fatty acid degradation and synthesis (Sections 23-1 through 23-5)**
Fatty acids are broken down in increments of C_2 units through β oxidation to form acetyl-CoA. They are synthesized from this compound via a separate pathway. The activity of the β-oxidation pathway varies with the fatty acid concentration. This, in turn, depends on the activity of "hormone-sensitive" triacylglycerol lipase in adipose tissue that is stimulated, through cAMP-regulated phosphorylation/dephosphorylation reactions, by glucagon and epinephrine but inhibited by insulin. The fatty acid synthesis rate varies with the activity of acetyl-CoA carboxylase, which is activated by citrate and inhibited by the pathway product palmitoyl-CoA. Fatty acid synthesis is also subject to long-term regulation through alterations in the rates of synthesis of the enzymes mediating this process as stimulated by insulin and inhibited by fasting.

5. **Citric acid cycle (Chapter 19)**
The citric acid cycle oxidizes acetyl-CoA, the common degradation product of glucose, fatty acids, and ketogenic amino acids, to CO_2 and H_2O with the concomitant production of NADH and $FADH_2$. Many glucogenic amino acids can also be oxidized via the citric acid cycle through their breakdown to one of its intermediates (Section 24-3). The activities of the citric acid cycle regulatory enzymes, citrate synthase, isocitrate dehydrogenase, and α-ketoglutarate dehydrogenase, are controlled by substrate availability and feedback inhibition by cycle intermediates.

6. **Oxidative phosphorylation (Chapter 20)**
This mitochondrial pathway oxidizes NADH and $FADH_2$ to NAD^+ and FAD with the coupled synthesis of ATP. The rate of oxidative phosphorylation, which is tightly coordinated with the metabolic fluxes through glycolysis and the citric acid cycle, is largely dependent on the concentrations of ATP, ADP, and P_i.

7. **Pentose phosphate pathway (Section 21-4)**
This pathway functions to generate NADPH for use in reductive biosynthesis, as well as the nucleotide precursor ribose-5-phosphate, through the oxidation of G6P. Its flux-generating step is catalyzed by glucose-6-phosphate dehydrogenase, which is controlled by the level of $NADP^+$. *The ability of enzymes to distinguish between NADH, which is mainly utilized in energy metabolism, and NADPH permits energy metabolism and biosynthesis to be regulated independently.*

8. **Amino acid degradation and synthesis (Sections 24-1 through 24-5)**
Excess amino acids may be degraded to common metabolic intermediates. Most of these pathways begin with an amino acid's transamination to its corresponding α-keto acid with the eventual transfer of the amino group to urea via the urea cycle. Leucine and lysine are ketogenic amino acids in that they can be converted only to acetyl-CoA or acetoacetate and hence cannot be glucose precursors. The other amino acids are glucogenic in that they may be, at least in part, converted to one of the glucose precursors—pyruvate, oxaloacetate, α-ketoglutarate, succinyl-CoA, or fumarate. Five amino acids are both ketogenic and glucogenic. Essential amino acids are those that an animal cannot synthesize itself; they must be obtained from plant and microbial sources. Nonessential amino acids can be synthesized by animals via pathways that are generally simpler than those synthesizing essential amino acids.

Two compounds lie at the crossroads of the foregoing metabolic pathways: acetyl-CoA and pyruvate (Fig. 25-1). Acetyl-CoA is the common degradation product of most metabolic fuels, including polysaccharides, lipids, and proteins. Its acetyl group may be oxidized to CO_2 and H_2O via the citric acid cycle and oxidative phosphorylation or used to synthesize fatty acids. Pyruvate is the product of glycolysis, the dehydrogenation of lactate, and the breakdown of certain glucogenic amino acids. It may be oxidatively decarboxylated to yield acetyl-CoA, thereby committing its atoms either to oxidation or to the biosynthesis of fatty acids. Alternatively, it may be carboxylated via the pyruvate carboxylase reaction to form oxaloacetate which, in turn, either replenishes citric acid cycle intermediates or enters gluconeogenesis via phosphoenolpyruvate, thereby bypassing an irreversible step in glycolysis. Pyruvate is therefore a precursor of several amino acids as well as of glucose.

The foregoing pathways occur in specific cellular compartments. Glycolysis, glycogen synthesis and degradation, fatty acid synthesis, and the pentose phosphate pathway are largely or entirely cytosolically based, whereas fatty acid degradation, the citric acid cycle, and oxidative phosphorylation occur largely in the mitochondrion. Different phases of gluconeogenesis and amino acid degradation occur in each of these compartments. *The flow of metabolites across compartment membranes is mediated, in most cases, by specific carriers that are also subject to regulation.*

The enormous number of enzymatic reactions that simultaneously occur in every cell (Fig. 15-1) must be coordinated and strictly controlled to meet the cell's needs. Such

regulation occurs on many levels. Intercellular communications regulating metabolism occur via certain hormones, including epinephrine, norepinephrine, glucagon, and insulin, as well as through a series of steroid hormones known as **glucocorticoids** (whose actions are discussed in Section 34-4A). These hormonal signals trigger a variety of cellular responses, including the synthesis of second messengers such as cAMP in the short term and the modulation of protein synthesis rates in the long term. On the molecular level, the enzymatic reaction rates are controlled by phosphorylation/dephosphorylation via amplifying reaction cascades, by allosteric responses to the presence of effectors, which are usually precursors or products of the reaction pathway being controlled, and by substrate availability. The regulatory machinery of opposing catabolic and anabolic pathways is generally arranged such that these pathways are reciprocally regulated.

2. ORGAN SPECIALIZATION

In this section we consider how the special needs of the mammalian body organs are met and how their metabolic capabilities are coordinated to meet these needs. In particular, we discuss brain, muscle, adipose tissue, and liver (Fig. 25-2).

A. Brain

Brain tissue has a remarkably high respiration rate. For instance, the human brain only constitutes ~2% of the adult body mass but is responsible for ~20% of its resting O_2 consumption. This consumption, moreover, is independent of the state of mental activity; it varies little between sleep and the intense concentration required of, say, the study of biochemistry. Most of the brain's energy pro-

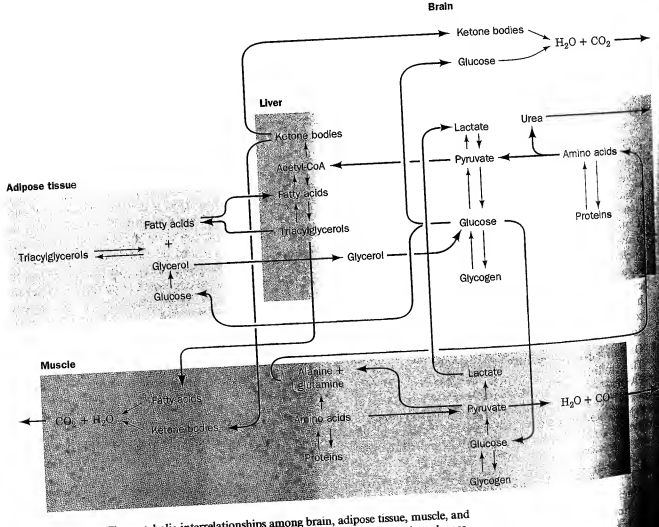


FIGURE 25-2. The metabolic interrelationships among brain, adipose tissue, muscle, and liver. The red arrows indicate pathways that predominate in the well-fed state when glucose, amino acids, and fatty acids are directly available from the intestines.

EXHIBIT G

DONALD VOET
University of Pennsylvania

JUDITH G. VOET
Swarthmore College

BIOCHEMISTRY

SECOND EDITION

JOHN WILEY & SONS, INC.
New York Chichester Brisbane
Toronto Singapore

Acquisitions Editor: *Nedah Rose*
Marketing Manager: *Catherine Faduska*
Designer: *Madelyn Lesure*
Manufacturing Manager: *Susan Stetzer*
Photo Researcher: *Hilary Newman*
Illustration Coordinator: *Edward Starr*
Illustrators: *J/B Woolsey Associates*
Production Management: *Pamela Kennedy Oborski and Suzanne Ingrao*
Cover and Part Opening Illustrations © *Irving Geis*
This book was set in 9.5/12 Times Roman by Progressive Information Technologies and printed and bound by Von Hoffman Press. The cover was printed by Lehigh Press Lithographers. Color separations by Lehigh Press Colortronics.

Cover Art: Two paintings of horse heart cytochrome *c* by Irving Geis in which the protein is illuminated by its single iron atom. On the front cover the hydrophilic side chains are drawn in green, and on the back cover the hydrophobic side chains are drawn in orange. The paintings are based on an X-ray structure by Richard Dickerson.

Recognizing the importance of preserving what has been written, it is a policy of John Wiley & Sons, Inc. to have books of enduring value published in the United States printed on acid-free paper, and we exert our best efforts to that end.

John Wiley & Sons, Inc., places great value on the environment and is actively involved in efforts to preserve it. Currently, paper of high enough quality to reproduce full-color art effectively contains a maximum of 10% recovered and recycled post-consumer fiber. Wherever possible, Wiley uses paper containing the maximum amount of recycled fibers. In addition, the paper in this book was manufactured by a mill whose forest management programs include sustained yield harvesting of its timberlands. Sustained yield harvesting principles ensure that the number of trees cut each year does not exceed the amount of new growth.

TOTAL 10% RECYCLED PAPER
ALL POST-CONSUMER WASTE

ISBN: 0-471-58651-X

Printed in the United States of America

10 9 8 7 6 5 4 3 2

inhibitor binds essentially irreversibly to any trypsin formed in the pancreas so as to inactivate it. Furthermore, the trypsin-catalyzed activation of trypsinogen (Fig. 14-26) occurs quite slowly, presumably because the unusually large negative charge of its highly evolutionarily conserved N-terminal hexapeptide repels the Asp at the back of trypsin's specificity pocket. Finally, pancreatic zymogens are stored in intracellular vesicles called **zymogen granules** whose membranous walls are thought to be resistant to enzymatic degradation.

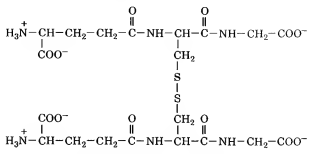
Zymogens Have Distorted Active Sites

Since the zymogens of trypsin, chymotrypsin, and elastase have all their catalytic residues, why aren't they enzymatically active? Comparisons of the X-ray structures of trypsinogen with that of trypsin and of chymotrypsinogen with that of chymotrypsin show that upon activation, the newly liberated N-terminal Ile 16 residue moves from the surface of the protein to an internal position, where its free cationic amino group forms an ion pair with the invariant anionic Asp 194 (Fig. 14-21). Aside from this change, however, the structures of these zymogens closely resemble those of their corresponding active enzymes. Surprisingly, this resemblance includes their catalytic triads, an observation which led to the discovery that these zymogens are actually enzymatically active, albeit at a very low level. Careful comparisons of the corresponding enzyme and zymogen structures, however, revealed the reason for this low activity: *The zymogens' specificity pockets and oxyanion holes are improperly formed such that, for example, the amide NH of chymotrypsin's Gly 193 points in the wrong direction to form a hydrogen bond with the tetrahedral intermediate (see Fig. 14-25).* Hence, the zymogens' very low enzymatic activity arises from their reduced ability to bind substrate productively and to stabilize the tetrahedral intermediate. These observations provide further structural evidence favoring the role of transition state binding in the catalytic mechanism of serine proteases.

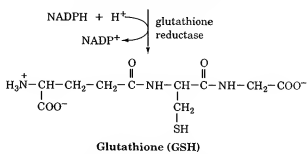
4. GLUTATHIONE REDUCTASE

Lysozyme and the serine proteases all catalyze hydrolytic reactions. In contrast, the third enzyme that we shall consider in mechanistic detail, **glutathione reductase,** catalyzes an oxidation–reduction reaction. Such reactions are extremely important in metabolic processes. We have chosen to study gluthathione reductase, which sequentially catalyzes several electron-transfer processes, because it is one of the few such enzymes in which the pathway of electron flow has been well characterized.

Glutathione reductase is a nearly ubiquitous enzyme that catalyzes the NADPH-dependent reduction of **glutathione disulfide (GSSG)** to **glutathione (GSH):**



Glutathione disulfide (GSSG)

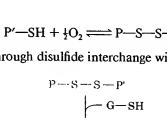


Glutathione (GSH)
(γ-L-Glutamyl-L-cysteinyl glycine)

(the structures of $NADP^+$ and NADPH are indicated in Fig. 12-2). This process normally produces a GSH:GSSG ratio of over 100:1, which permits GSH to function as an intracellular reducing agent (the thermodynamics of oxidation–reduction reactions is discussed in Section 15-5). For example, the inactivation of proteins (P) that have free SH groups through the spontaneous oxidative formation of mixed disulfides

$$P\text{—}SH + P'\text{—}SH + \tfrac{1}{2}O_2 \rightleftharpoons P\text{—}S\text{—}S\text{—}P' + H_2O$$

is reversed through disulfide interchange with GSH.



GSH also acts as a coenzyme in several enzymatically catalyzed reductions and plays an important role in the transport of amino acids into certain cells (Section 24-4C).

FAD Is an Essential Redox Coenzyme

Glutathione reductase contains the electron-transfer prosthetic group **flavin adenine dinucleotide (FAD;** Fig. 14-28). **Flavins** (substances that contain the **isoalloxazine** ring) can undergo two sequential one-electron transfers (Fig. 14-28), or a simultaneous two-electron transfer that bypasses the semiquinone state. The glutathione reductase reaction involves the simultaneous transfer of two electrons so that,

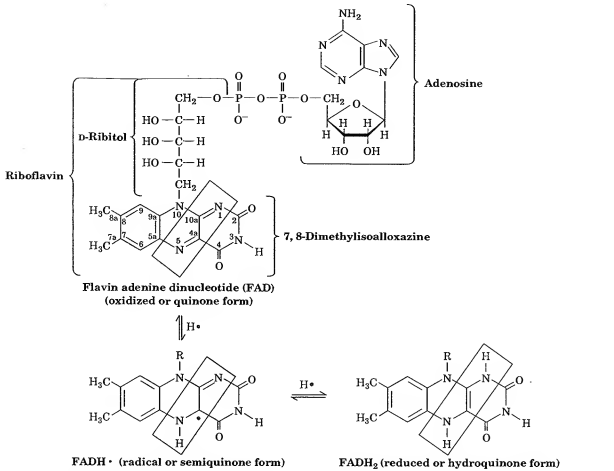


FIGURE 14-28. The molecular formula and reactions of the coenzyme flavin adenine dinucleotide (FAD). The term "flavin" is synonymous with the isoalloxazine ring system. The D-ribitol residue is derived from the alcohol of the sugar D-ribose. FAD may be half-reduced to the stable radical FADH· or fully reduced to $FADH_2$ (*boxes*). Consequently, different FAD-containing enzymes cycle between different oxidation states of FAD. FAD is usually tightly bound to its enzymes so that this coenzyme normally is a prosthetic group rather than a cosubstrate as is the case, for example, with NAD^+.

in this case, the FAD never assumes its radical form. The oxidation state of the flavin in a **flavoprotein** (flavin-containing protein) is readily established from its characteristic UV–visible spectrum: FAD is an intense yellow, whereas $FADH_2$ is pale yellow.

Humans and other higher animals are unable to synthesize the isoalloxazine component of flavins, so they must obtain this substance from their diets, for example, in the form of **riboflavin (vitamin B_2)** (Fig. 14-28). Riboflavin deficiency is quite rare in humans, in part because of the tight binding of flavin prosthetic groups to their apoenzymes. The symptoms of riboflavin deficiency, which are associated with general malnutrition or bizarre diets, include an inflamed tongue, lesions in the corners of the mouth, and dermatitis.

Glutathione Reductase Catalyzes a Two-Stage Reaction

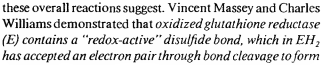
Glutathione reductase from human erythrocytes is a dimer of identical 478-residue subunits that are covalently linked by an intersubunit disulfide bond. In the absence of GSSG, the enzyme catalyzes the first stage of a two-stage reaction:

First stage: $E + NADPH + H^+ \rightleftharpoons EH_2 + NADP^+$

where E represents fully oxidized glutathione reductase and EH_2 is a stable two-electron reduced intermediate whose chemical nature we shall presently discuss. Upon subsequent addition of GSSG, EH_2 reacts to form products and complete the catalytic cycle.

Second stage: $EH_2 + GSSG \rightleftharpoons E + 2GSH$

The glutathione reductase reaction is more complex than these overall reactions suggest. Vincent Massey and Charles Williams demonstrated that *oxidized glutathione reductase (E) contains a "redox-active" disulfide bond, which in EH_2 has accepted an electron pair through bond cleavage to form a dithiol.*



APPENDIX B

NCBI PubMed www.pubmed.gov

A service of the National Library of Medicine and the National Institutes of Health

My NCBI [Sign In] [Reg

All Databases PubMed Nucleotide Protein Genome Structure OMIM PMC Journals B

Search PubMed for nadh Go Clear Save S

Limits Preview/Index History Clipboard Details

Field: **Title**, Limits: **Publication Date from 2002 to 2002**

About Entrez

Text Version

Display Summary Show 200 Sort by Send to

All: 124 Review: 6

Items 1 - 124 of 124 One page.

Entrez PubMed
Overview
Help | FAQ
Tutorials
New/Noteworthy
E-Utilities

PubMed Services
Journals Database
MeSH Database
Single Citation Matcher
Batch Citation Matcher
Clinical Queries
Special Queries
LinkOut
My NCBI

Related Resources
Order Documents
NLM Mobile
NLM Catalog
NLM Gateway
TOXNET
Consumer Health
Clinical Alerts
ClinicalTrials.gov
PubMed Central

1: Haldimann P, Tsimilli-Michael M. Related Articles, Links

Mercury inhibits the non-photochemical reduction of plastoquinone by exogenous NADPH and NADH: evidence from measurements of the polyphasic chlorophyll a fluorescence rise in spinach chloroplasts.
Photosynth Res. 2002;74(1):37-50.
PMID: 16228543 [PubMed - as supplied by publisher]

2: Pagala VR, Park J, Reed DW, Hartzell PL. Related Articles, Links

Cellular localization of D-lactate dehydrogenase and NADH oxidase from Archaeoglobus fulgidus.
Archaea. 2002 Sep;1(2):95-104.
PMID: 15803647 [PubMed - indexed for MEDLINE]

3: Kedar PS, Colah RB, Ghosh K, Mohanty D. Related Articles, Links

Congenital methemoglobinemia due to NADH-methemoglobin reductase deficiency in three Indian families.
Haematologia (Budap). 2002;32(4):543-9.
PMID: 12803131 [PubMed - indexed for MEDLINE]

4: Averet N, Aguilaniu H, Bunoust O, Gustafsson L, Rigoulet M. Related Articles, Links

NADH is specifically channeled through the mitochondrial porin channel in Saccharomyces cerevisiae.
J Bioenerg Biomembr. 2002 Dec;34(6):499-506.
PMID: 12678441 [PubMed - indexed for MEDLINE]

5: Birkmayer JG, Nadlinger K. Related Articles, Links

Safety of stabilized, orally absorbable, reduced nicotinamide adenine dinucleotide (NADH): a 26-week oral tablet administration of ENADA/NADH for chronic toxicity study in rats.
Drugs Exp Clin Res. 2002;28(5):185-92.
PMID: 12635493 [PubMed - indexed for MEDLINE]

6: Berrios-Rivera SJ, San KY, Bennett GN. Related Articles, Links

The effect of NAPRTase overexpression on the total levels of NAD, the NADH/NAD+ ratio, and the distribution of metabolites in Escherichia coli.
Metab Eng. 2002 Jul;4(3):238-47.
PMID: 12616693 [PubMed - indexed for MEDLINE]

☐ **7:** Berrios-Rivera SJ, Bennett GN, San KY. Related Articles, Links

The effect of increasing NADH availability on the redistribution of metabolic fluxes in Escherichia coli chemostat cultures.
Metab Eng. 2002 Jul;4(3):230-7.
PMID: 12616692 [PubMed - indexed for MEDLINE]

☐ **8:** Berrios-Rivera SJ, Bennett GN, San KY. Related Articles, Links

Metabolic engineering of Escherichia coli: increase of NADH availability by overexpressing an NAD(+)-dependent formate dehydrogenase.
Metab Eng. 2002 Jul;4(3):217-29.
PMID: 12616691 [PubMed - indexed for MEDLINE]

☐ **9:** Zakharova NV, Zharova TV. Related Articles, Links

Kinetic mechanism of mitochondrial NADH:ubiquinone oxidoreductase interaction with nucleotide substrates of the transhydrogenase reaction.
Biochemistry (Mosc). 2002 Dec;67(12):1395-404.
PMID: 12600270 [PubMed - indexed for MEDLINE]

☐ **10:** Nakano K, Takeo T, Sato T, Suga S, Eto K, Kadowaki T, Wakui M. Related Articles, Links

Role of mitochondrial NADH shuttle system in acute amylase secretion by acetylcholine from mouse pancreatic acinar cells.
Tohoku J Exp Med. 2002 Nov;198(3):151-62.
PMID: 12597242 [PubMed - indexed for MEDLINE]

☐ **11:** Lo HC, Fish RH. Related Articles, Links

Biomimetic NAD(+) models for tandem cofactor regeneration, horse liver alcohol dehydrogenase recognition of 1,4-NADH derivatives, and chiral synthesis.
Angew Chem Int Ed Engl. 2002 Feb 1;41(3):478-81. No abstract available.
PMID: 12491384 [PubMed - indexed for MEDLINE]

☐ **12:** Banta S, Anderson S. Related Articles, Links

Verification of a novel NADH-binding motif: combinatorial mutagenesis of three amino acids in the cofactor-binding pocket of Corynebacterium 2,5-diketo-D-gluconic acid reductase.
J Mol Evol. 2002 Dec;55(6):623-31.
PMID: 12486521 [PubMed - indexed for MEDLINE]

☐ **13:** Okinaka Y, Yang CH, Herman E, Kinney A, Keen NT. Related Articles, Links

The P34 syringolide elicitor receptor interacts with a soybean photorespiration enzyme, NADH-dependent hydroxypyruvate reductase.
Mol Plant Microbe Interact. 2002 Dec;15(12):1213-8.
PMID: 12481993 [PubMed - indexed for MEDLINE]

☐ **14:** Harmych S, Arnette R, Komuniecki R. Related Articles, Links

Role of dihydrolipoyl dehydrogenase (E3) and a novel E3-binding protein in the NADH sensitivity of the pyruvate dehydrogenase complex from anaerobic mitochondria of the parasitic nematode, Ascaris suum.
Mol Biochem Parasitol. 2002 Nov-Dec;125(1-2):135-46.
PMID: 12467981 [PubMed - indexed for MEDLINE]

☐ **15:** Fukuzumi S, Inada O, Suenobu T. Related Articles, Links

Direct detection of radical cations of NADH analogues.
J Am Chem Soc. 2002 Dec 11;124(49):14538-9. No abstract available.
PMID: 12465955 [PubMed - indexed for MEDLINE]

☐16: Mathiesen C, Hagerhall C. Related Articles, Links

Transmembrane topology of the NuoL, M and N subunits of NADH:quinone oxidoreductase and their homologues among membrane-bound hydrogenases and bona fide antiporters.
Biochim Biophys Acta. 2002 Dec 2;1556(2-3):121-32.
PMID: 12460669 [PubMed - indexed for MEDLINE]

☐17: Bogachev AV, Bertsova YV, Ruuge EK, Wikstrom M, Verkhovsky MI. Related Articles, Links

Kinetics of the spectral changes during reduction of the Na+-motive NADH:quinone oxidoreductase from Vibrio harveyi.
Biochim Biophys Acta. 2002 Dec 2;1556(2-3):113-20.
PMID: 12460668 [PubMed - indexed for MEDLINE]

☐18: Kimura S, Kawamura M, Iyanagi T. Related Articles, Links

Role of Thr(66) in porcine NADH-cytochrome b5 reductase in catalysis and control of the rate-limiting step in electron transfer.
J Biol Chem. 2003 Feb 7;278(6):3580-9. Epub 2002 Nov 28.
PMID: 12459552 [PubMed - indexed for MEDLINE]

☐19: Nixon JE, Wang A, Field J, Morrison HG, McArthur AG, Sogin ML, Loftus BJ, Samuelson J. Related Articles, Links

Evidence for lateral transfer of genes encoding ferredoxins, nitroreductases, NADH oxidase, and alcohol dehydrogenase 3 from anaerobic prokaryotes to Giardia lamblia and Entamoeba histolytica.
Eukaryot Cell. 2002 Apr;1(2):181-90.
PMID: 12455953 [PubMed - indexed for MEDLINE]

☐20: Neves AR, Ramos A, Costa H, van Swam II, Hugenholtz J, Kleerebezem M, de Vos W, Santos H. Related Articles, Links

Effect of different NADH oxidase levels on glucose metabolism by Lactococcus lactis: kinetics of intracellular metabolite pools determined by in vivo nuclear magnetic resonance.
Appl Environ Microbiol. 2002 Dec;68(12):6332-42.
PMID: 12450858 [PubMed - indexed for MEDLINE]

☐21: Morre DJ, Penel C, Greppin H, Morre DM. Related Articles, Links

The plasma membrane-associated NADH oxidase of spinach leaves responds to blue light.
Int J Plant Sci. 2002 Jul;163(4):543-7.
PMID: 12448422 [PubMed - indexed for MEDLINE]

☐22: Flemming D, Hellwig P, Friedrich T. Related Articles, Links

Involvement of tyrosines 114 and 139 of subunit NuoB in the proton pathway around cluster N2 in Escherichia coli NADH:ubiquinone oxidoreductase.
J Biol Chem. 2003 Jan 31;278(5):3055-62. Epub 2002 Nov 20.
PMID: 12446673 [PubMed - indexed for MEDLINE]

☐23: Kumar P, Pai K, Pandey HP, Sundar S. Related Articles, Links

NADH-oxidase, NADPH-oxidase and myeloperoxidase activity of

visceral leishmaniasis patients.
J Med Microbiol. 2002 Oct;51(10):832-6.
PMID: 12435061 [PubMed - indexed for MEDLINE]

☐24: Harrison M, Singh SM. Related Articles, Links

Genetics and differential expression of NADH:ubiquinone oxidoreductase B8 subunit in brains of genetic strains of mice differing in voluntary alcohol consumption.
Biochim Biophys Acta. 2002 Dec 12;1579(2-3):164-72.
PMID: 12427551 [PubMed - indexed for MEDLINE]

☐25: Holtz KM, Rockwell S, Tomasz M, Sartorelli AC. Related Articles, Links

Nuclear overexpression of NADH:cytochrome b5 reductase activity increases the cytotoxicity of mitomycin C (MC) and the total number of MC-DNA adducts in Chinese hamster ovary cells.
J Biol Chem. 2003 Feb 14;278(7):5029-34. Epub 2002 Nov 6.
PMID: 12424239 [PubMed - indexed for MEDLINE]

☐26: Bandeiras TM, Salgueiro C, Kletzin A, Gomes CM, Teixeira M. Related Articles, Links

Acidianus ambivalens type-II NADH dehydrogenase: genetic characterisation and identification of the flavin moiety as FMN.
FEBS Lett. 2002 Nov 6;531(2):273-7.
PMID: 12417325 [PubMed - indexed for MEDLINE]

☐27: Hanley PJ, Ray J, Brandt U, Daut J. Related Articles, Links

Halothane, isoflurane and sevoflurane inhibit NADH:ubiquinone oxidoreductase (complex I) of cardiac mitochondria.
J Physiol. 2002 Nov 1;544(Pt 3):687-93.
PMID: 12411515 [PubMed - indexed for MEDLINE]

☐28: Reichenbach-Klinke R, Kruppa M, Konig B. Related Articles, Links

NADH model systems functionalized with Zn(II)-cyclen as flavin binding site-structure dependence of the redox reaction within reversible aggregates.
J Am Chem Soc. 2002 Nov 6;124(44):12999-3007.
PMID: 12405826 [PubMed - indexed for MEDLINE]

☐29: Nadlinger K, Westerthaler W, Storga-Tomic D, Birkmayer JG. Related Articles, Links

Extracellular metabolisation of NADH by blood cells correlates with intracellular ATP levels.
Biochim Biophys Acta. 2002 Nov 14;1573(2):177-82.
PMID: 12399028 [PubMed - indexed for MEDLINE]

☐30: Vasse JL, Levacher V, Bourguignon J, Dupas G. Related Articles, Links

Atropoisomeric quinolinium salt promoting the access to both enantiomeric forms of methyl mandelate: a versatile NADH mimic.
Chem Commun (Camb). 2002 Oct 7;(19):2256-7.
PMID: 12398004 [PubMed - indexed for MEDLINE]

☐31: Percy MJ, Gillespie MJ, Savage G, Hughes AE, McMullin MF, Lappin TR. Related Articles, Links

Familial idiopathic methemoglobinemia revisited: original cases reveal 2 novel mutations in NADH-cytochrome b5 reductase.
Blood. 2002 Nov 15;100(10):3447-9. Epub 2002 Jul 5.

PMID: 12393396 [PubMed - indexed for MEDLINE]

☐ **32:** Cocco T, Cutecchia G, Montedoro G, Lorusso M. Related Articles, Links

The antihypertensive drug carvedilol inhibits the activity of mitochondrial NADH-ubiquinone oxidoreductase.
J Bioenerg Biomembr. 2002 Aug;34(4):251-8.
PMID: 12392188 [PubMed - indexed for MEDLINE]

☐ **33:** Liu FQ, Zhang JR. Related Articles, Links

Effect of NADH against liver cell line L02 apoptosis induced by UVB irradiation.
Di Yi Jun Yi Da Xue Xue Bao. 2002 Mar;22(3):232-4.
PMID: 12390773 [PubMed - indexed for MEDLINE]

☐ **34:** Birkmayer GD, Kay GG, Vurre E. Related Articles, Links

[Stabilized NADH (ENADA) improves jet lag-induced cognitive performance deficit]
Wien Med Wochenschr. 2002;152(17-18):450-4. German.
PMID: 12385067 [PubMed - indexed for MEDLINE]

☐ **35:** Elmore CL, Porter TD. Related Articles, Links

Modification of the nucleotide cofactor-binding site of cytochrome P-450 reductase to enhance turnover with NADH in Vivo.
J Biol Chem. 2002 Dec 13;277(50):48960-4. Epub 2002 Oct 14.
PMID: 12381719 [PubMed - indexed for MEDLINE]

☐ **36:** Prasad GS, Wahlberg M, Sridhar V, Sundaresan V, Yamaguchi M, Hatefi Y, Stout CD. Related Articles, Links

Crystal structures of transhydrogenase domain I with and without bound NADH.
Biochemistry. 2002 Oct 22;41(42):12745-54.
PMID: 12379117 [PubMed - indexed for MEDLINE]

☐ **37:** Tan C, Tuch BE, Tu J, Brown SA. Related Articles, Links

Role of NADH shuttles in glucose-induced insulin secretion from fetal beta-cells.
Diabetes. 2002 Oct;51(10):2989-96. Erratum in: Diabetes 2003 Jan;52(1):224.
PMID: 12351438 [PubMed - indexed for MEDLINE]

☐ **38:** Drose S, Zwicker K, Brandt U. Related Articles, Links

Full recovery of the NADH:ubiquinone activity of complex I (NADH:ubiquinone oxidoreductase) from Yarrowia lipolytica by the addition of phospholipids.
Biochim Biophys Acta. 2002 Oct 3;1556(1):65-72.
PMID: 12351219 [PubMed - indexed for MEDLINE]

☐ **39:** Maklashina E, Sher Y, Zhou HZ, Gray MO, Karliner JS, Cecchini G. Related Articles, Links

Effect of anoxia/reperfusion on the reversible active/de-active transition of NADH-ubiquinone oxidoreductase (complex I) in rat heart.
Biochim Biophys Acta. 2002 Oct 3;1556(1):6-12.
PMID: 12351213 [PubMed - indexed for MEDLINE]

☐ **40:** Fang J, Beattie DS. Related Articles, Links

Rotenone-insensitive NADH dehydrogenase is a potential source of superoxide in procyclic Trypanosoma brucei mitochondria.
Mol Biochem Parasitol. 2002 Aug 28;123(2):135-42.
PMID: 12270629 [PubMed - indexed for MEDLINE]

☐ **41:** Eto K, Kadowaki T. Related Articles, Links

[Role of NADH shuttle system in glucose-stimulated insulin secretion]
Nippon Rinsho. 2002 Jul;60 Suppl 7:190-207. Review. Japanese. No abstract available.
PMID: 12238047 [PubMed - indexed for MEDLINE]

☐ **42:** Seo BB, Nakamaru-Ogiso E, Flotte TR, Yagi T, Matsuno-Yagi A. Related Articles, Links

A single-subunit NADH-quinone oxidoreductase renders resistance to mammalian nerve cells against complex I inhibition.
Mol Ther. 2002 Sep;6(3):336-41. Erratum in: Mol Ther. 2003 Jun;7(6):859.
PMID: 12231169 [PubMed - indexed for MEDLINE]

☐ **43:** Yano T. Related Articles, Links

The energy-transducing NADH: quinone oxidoreductase, complex I.
Mol Aspects Med. 2002 Oct;23(5):345-68. Review.
PMID: 12231006 [PubMed - indexed for MEDLINE]

☐ **44:** Denicola A, Rubbo H, Haden L, Turrens JF. Related Articles, Links

Extramitochondrial localization of NADH-fumarate reductase in trypanosomatids.
Comp Biochem Physiol B Biochem Mol Biol. 2002 Sep;133(1):23-7.
PMID: 12223208 [PubMed - indexed for MEDLINE]

☐ **45:** Videira A, Duarte M. Related Articles, Links

From NADH to ubiquinone in Neurospora mitochondria.
Biochim Biophys Acta. 2002 Sep 10;1555(1-3):187-91. Review.
PMID: 12206913 [PubMed - indexed for MEDLINE]

☐ **46:** Olek RA, Antosiewicz J, Caulini GC, Falcioni G. Related Articles, Links

Effect of NADH on the redox state of human hemoglobin.
Clin Chim Acta. 2002 Oct;324(1-2):129-34.
PMID: 12204434 [PubMed - indexed for MEDLINE]

☐ **47:** Buchner M, Huber R, Sturchler-Pierrat C, Staufenbiel M, Riepe MW. Related Articles, Links

Impaired hypoxic tolerance and altered protein binding of NADH in presymptomatic APP23 transgenic mice.
Neuroscience. 2002;114(2):285-9.
PMID: 12204198 [PubMed - indexed for MEDLINE]

☐ **48:** Huang GL, Zhang G, Gao Y, Zhu JW. Related Articles, Links

[Role of NADH-cytochrome b(5) reductase in biosynthesis of thyroid hydrogen peroxide]
Sheng Li Xue Bao. 2002 Aug 25;54(4):349-53. Chinese.
PMID: 12195287 [PubMed - in process]

☐ **49:** Kotlyar AB, Borovok N. Related Articles, Links

NADH oxidation and NAD+ reduction catalysed by tightly coupled inside-out vesicles from Paracoccus denitrificans.
Eur J Biochem. 2002 Aug;269(16):4020-4.

PMID: 12180978 [PubMed - indexed for MEDLINE]

☐ **50:** Rapisarda VA, Chehin RN, De Las Rivas J, Rodriguez-Montelongo L, Farias RN, Massa EM. Related Articles, Links

Evidence for Cu(I)-thiolate ligation and prediction of a putative copper-binding site in the Escherichia coli NADH dehydrogenase-2.
Arch Biochem Biophys. 2002 Sep 1;405(1):87-94.
PMID: 12176061 [PubMed - indexed for MEDLINE]

☐ **51:** Magnitsky S, Toulokhonova L, Yano T, Sled VD, Hagerhall C, Grivennikova VG, Burbaev DS, Vinogradov AD, Ohnishi T. Related Articles, Links

EPR characterization of ubisemiquinones and iron-sulfur cluster N2, central components of the energy coupling in the NADH-ubiquinone oxidoreductase (complex I) in situ.
J Bioenerg Biomembr. 2002 Jun;34(3):193-208.
PMID: 12171069 [PubMed - indexed for MEDLINE]

☐ **52:** Noda M, Yamashita S, Takahashi N, Eto K, Shen LM, Izumi K, Daniel S, Tsubamoto Y, Nemoto T, Iino M, Kasai H, Sharp GW, Kadowaki T. Related Articles, Links

Switch to anaerobic glucose metabolism with NADH accumulation in the beta-cell model of mitochondrial diabetes. Characteristics of betaHC9 cells deficient in mitochondrial DNA transcription.
J Biol Chem. 2002 Nov 1;277(44):41817-26. Epub 2002 Aug 6.
PMID: 12169697 [PubMed - indexed for MEDLINE]

☐ **53:** Martin-Romero FJ, Garcia-Martin E, Gutierrez-Merino C. Related Articles, Links

Inhibition of oxidative stress produced by plasma membrane NADH oxidase delays low-potassium-induced apoptosis of cerebellar granule cells.
J Neurochem. 2002 Aug;82(3):705-15.
PMID: 12153494 [PubMed - indexed for MEDLINE]

☐ **54:** Martin-Romero FJ, Gutierrez-Martin Y, Henao F, Gutierrez-Merino C. Related Articles, Links

The NADH oxidase activity of the plasma membrane of synaptosomes is a major source of superoxide anion and is inhibited by peroxynitrite.
J Neurochem. 2002 Aug;82(3):604-14.
PMID: 12153484 [PubMed - indexed for MEDLINE]

☐ **55:** Zu Y, Di Bernardo S, Yagi T, Hirst J. Related Articles, Links

Redox properties of the [2Fe-2S] center in the 24 kDa (NQO2) subunit of NADH:ubiquinone oxidoreductase (complex I).
Biochemistry. 2002 Aug 6;41(31):10056-69.
PMID: 12146970 [PubMed - indexed for MEDLINE]

☐ **56:** Besteiro S, Biran M, Biteau N, Coustou V, Baltz T, Canioni P, Bringaud F. Related Articles, Links

Succinate secreted by Trypanosoma brucei is produced by a novel and unique glycosomal enzyme, NADH-dependent fumarate reductase.
J Biol Chem. 2002 Oct 11;277(41):38001-12. Epub 2002 Jul 22.
PMID: 12138089 [PubMed - indexed for MEDLINE]

☐ **57:** Zakharova NV. Related Articles, Links

Kinetics of the transhydrogenase reaction catalyzed by mitochondrial NADH:ubiquinone oxidoreductase (complex I).

Biochemistry (Mosc). 2002 Jun;67(6):651-61.
PMID: 12126472 [PubMed - indexed for MEDLINE]

☐ **58:** Anderson RE, Meyer FB. Related Articles, Links

In vivo fluorescent imaging of NADH redox state in brain.
Methods Enzymol. 2002;352:482-94. No abstract available.
PMID: 12125373 [PubMed - indexed for MEDLINE]

☐ **59:** Brandes R, Bers DM. Related Articles, Links

Simultaneous measurements of mitochondrial NADH and Ca(2+) during increased work in intact rat heart trabeculae.
Biophys J. 2002 Aug;83(2):587-604.
PMID: 12124250 [PubMed - indexed for MEDLINE]

☐ **60:** Barquera B, Zhou W, Morgan JE, Gennis RB. Related Articles, Links

Riboflavin is a component of the Na+-pumping NADH-quinone oxidoreductase from Vibrio cholerae.
Proc Natl Acad Sci U S A. 2002 Aug 6;99(16):10322-4. Epub 2002 Jul 16.
PMID: 12122213 [PubMed - indexed for MEDLINE]

☐ **61:** Camacho Carvajal MM, Wijfjes AH, Mulders IH, Lugtenberg BJ, Bloemberg GV. Related Articles, Links

Characterization of NADH dehydrogenases of Pseudomonas fluorescens WCS365 and their role in competitive root colonization.
Mol Plant Microbe Interact. 2002 Jul;15(7):662-71.
PMID: 12118882 [PubMed - indexed for MEDLINE]

☐ **62:** Zhang L, Kudo T, Takaya N, Shoun H. Related Articles, Links

The B' helix determines cytochrome P450nor specificity for the electron donors NADH and NADPH.
J Biol Chem. 2002 Sep 13;277(37):33842-7. Epub 2002 Jul 8.
PMID: 12105197 [PubMed - indexed for MEDLINE]

☐ **63:** McDonough JA, Bhattacherjee V, Sadlon T, Hostetter MK. Related Articles, Links

Involvement of Candida albicans NADH dehydrogenase complex I in filamentation.
Fungal Genet Biol. 2002 Jul;36(2):117-27.
PMID: 12081465 [PubMed - indexed for MEDLINE]

☐ **64:** Yeh JI, Claiborne A. Related Articles, Links

Crystal structures of oxidized and reduced forms of NADH peroxidase.
Methods Enzymol. 2002;353:44-54.
PMID: 12078517 [PubMed - indexed for MEDLINE]

☐ **65:** Rex A, Hentschke MP, Fink H. Related Articles, Links

Bioavailability of reduced nicotinamide-adenine-dinucleotide (NADH) in the central nervous system of the anaesthetized rat measured by laser-induced fluorescence spectroscopy.
Pharmacol Toxicol. 2002 Apr;90(4):220-5.
PMID: 12076318 [PubMed - indexed for MEDLINE]

☐ **66:** Taylor LM, Andrew Aquilina J, Jamie JF, Truscott RJ. Related Articles, Links

Glutathione and NADH, but not ascorbate, protect lens proteins from modification by UV filters.

Exp Eye Res. 2002 Apr;74(4):503-11.
PMID: 12076094 [PubMed - indexed for MEDLINE]

☐ 67: Valdez LB, Actis-Goretta L, Boveris A. Related Articles, Links

Polyphenols in red wines prevent NADH oxidation induced by peroxynitrite.
Ann N Y Acad Sci. 2002 May;957:274-8.
PMID: 12074980 [PubMed - indexed for MEDLINE]

☐ 68: Boveris A, Valdez L, Alvarez S. Related Articles, Links

Inhibition by wine polyphenols of peroxynitrite-initiated chemiluminescence and NADH oxidation.
Ann N Y Acad Sci. 2002 May;957:90-102. Review.
PMID: 12074964 [PubMed - indexed for MEDLINE]

☐ 69: Herles C, Braune A, Blaut M. Related Articles, Links

Purification and characterization of an NADH oxidase from Eubacterium ramulus.
Arch Microbiol. 2002 Jul;178(1):71-4. Epub 2002 May 7.
PMID: 12070772 [PubMed - indexed for MEDLINE]

☐ 70: Muhlenhoff U, Richhardt N, Gerber J, Lill R. Related Articles, Links

Characterization of iron-sulfur protein assembly in isolated mitochondria. A requirement for ATP, NADH, and reduced iron.
J Biol Chem. 2002 Aug 16;277(33):29810-6. Epub 2002 Jun 13.
PMID: 12065597 [PubMed - indexed for MEDLINE]

☐ 71: Riess ML, Camara AK, Chen Q, Novalija E, Rhodes SS, Stowe DF. Related Articles, Links

Altered NADH and improved function by anesthetic and ischemic preconditioning in guinea pig intact hearts.
Am J Physiol Heart Circ Physiol. 2002 Jul;283(1):H53-60.
PMID: 12063274 [PubMed - indexed for MEDLINE]

☐ 72: Svensson AS, Johansson FI, Moller IM, Rasmusson AG. Related Articles, Links

Cold stress decreases the capacity for respiratory NADH oxidation in potato leaves.
FEBS Lett. 2002 Apr 24;517(1-3):79-82.
PMID: 12062413 [PubMed - indexed for MEDLINE]

☐ 73: Hayashi M, Shibata N, Nakayama Y, Yoshikawa K, Unemoto T. Related Articles, Links

Korormicin insensitivity in Vibrio alginolyticus is correlated with a single point mutation of Gly-140 in the NqrB subunit of the Na(+)-translocating NADH-quinone reductase.
Arch Biochem Biophys. 2002 May 15;401(2):173-7.
PMID: 12054467 [PubMed - indexed for MEDLINE]

☐ 74: Duarte M, Populo H, Videira A, Friedrich T, Schulte U. Related Articles, Links

Disruption of iron-sulphur cluster N2 from NADH: ubiquinone oxidoreductase by site-directed mutagenesis.
Biochem J. 2002 Jun 15;364(Pt 3):833-9.
PMID: 12049648 [PubMed - indexed for MEDLINE]

☐ 75: Jensen Jr KA Jr, Ryan ZC, Vanden Wymelenberg A, Cullen D, Hammel KE. Related Articles, Links

An NADH:quinone oxidoreductase active during biodegradation by the brown-rot basidiomycete Gloeophyllum trabeum.
Appl Environ Microbiol. 2002 Jun;68(6):2699-703.
PMID: 12039722 [PubMed - indexed for MEDLINE]

☐ **76:** Raijmakers MT, Roes EM, Steegers EA, Peters WH. Related Articles, Links

The C242T-polymorphism of the NADPH/NADH oxidase gene p22phox subunit is not associated with pre-eclampsia.
J Hum Hypertens. 2002 Jun;16(6):423-5.
PMID: 12037698 [PubMed - indexed for MEDLINE]

☐ **77:** Deguchi T, Matsubara M, Nishida T. Related Articles, Links

NADH oxidation by manganese peroxidase with or without alpha-hydroxy acid.
Biosci Biotechnol Biochem. 2002 Apr;66(4):717-21.
PMID: 12036041 [PubMed - indexed for MEDLINE]

☐ **78:** Hammen PK, Allali-Hassani A, Hallenga K, Hurley TD, Weiner H. Related Articles, Links

Multiple conformations of NAD and NADH when bound to human cytosolic and mitochondrial aldehyde dehydrogenase.
Biochemistry. 2002 Jun 4;41(22):7156-68.
PMID: 12033950 [PubMed - indexed for MEDLINE]

☐ **79:** Pahlman IL, Larsson C, Averet N, Bunoust O, Boubekeur S, Gustafsson L, Rigoulet M. Related Articles, Links

Kinetic regulation of the mitochondrial glycerol-3-phosphate dehydrogenase by the external NADH dehydrogenase in Saccharomyces cerevisiae.
J Biol Chem. 2002 Aug 2;277(31):27991-5. Epub 2002 May 24.
PMID: 12032156 [PubMed - indexed for MEDLINE]

☐ **80:** Batchelor RH, Zhou M. Related Articles, Links

A resorufin-based fluorescent assay for quantifying NADH.
Anal Biochem. 2002 Jun 1;305(1):118-9. No abstract available.
PMID: 12018954 [PubMed - indexed for MEDLINE]

☐ **81:** Nakashima Y, Shinzawa-Itoh K, Watanabe K, Naoki K, Hano N, Yoshikawa S. Related Articles, Links

The second coenzyme Q1 binding site of bovine heart NADH: coenzyme Q oxidoreductase.
J Bioenerg Biomembr. 2002 Apr;34(2):89-94.
PMID: 12018892 [PubMed - indexed for MEDLINE]

☐ **82:** Murata M, Kawanishi S. Related Articles, Links

Oxidation of 5'-site guanine at GG and GGG sequences induced by a metabolite of carcinogenic heterocyclic amine PhIP in the presence of Cu (II) and NADH.
Carcinogenesis. 2002 May;23(5):855-60.
PMID: 12016160 [PubMed - indexed for MEDLINE]

☐ **83:** Miki T. Related Articles, Links

[Mitochondrial complex I (NADH-ubiquinone oxidoreductase)]
Nippon Rinsho. 2002 Apr;60 Suppl 4:135-8. Review. Japanese. No abstract available.
PMID: 12013836 [PubMed - indexed for MEDLINE]

☐ **84:** Neves AR, Ventura R, Mansour N, Shearman C, Gasson MJ, Maycock C, Ramos A, Santos H. Related Articles, Links

Is the glycolytic flux in Lactococcus lactis primarily controlled by the redox charge? Kinetics of NAD(+) and NADH pools determined in vivo by 13C NMR.
J Biol Chem. 2002 Aug 2;277(31):28088-98. Epub 2002 May 13.
PMID: 12011086 [PubMed - indexed for MEDLINE]

☐ **85:** Ellis EA, Guberski DL, Hutson B, Grant MB. Related Articles, Links

Time course of NADH oxidase, inducible nitric oxide synthase and peroxynitrite in diabetic retinopathy in the BBZ/WOR rat.
Nitric Oxide. 2002 May;6(3):295-304.
PMID: 12009847 [PubMed - indexed for MEDLINE]

☐ **86:** Bartlett PN, Simon E, Toh CS. Related Articles, Links

Modified electrodes for NADH oxidation and dehydrogenase-based biosensors.
Bioelectrochemistry. 2002 May 15;56(1-2):117-22.
PMID: 12009456 [PubMed - indexed for MEDLINE]

☐ **87:** Munteanu FD, Mano N, Kuhn A, Gorton L. Related Articles, Links

Mediator-modified electrodes for catalytic NADH oxidation: high rate constants at interesting overpotentials.
Bioelectrochemistry. 2002 May 15;56(1-2):67-72.
PMID: 12009446 [PubMed - indexed for MEDLINE]

☐ **88:** Mayr P, Nidetzky B. Related Articles, Links

Catalytic reaction profile for NADH-dependent reduction of aromatic aldehydes by xylose reductase from Candida tenuis.
Biochem J. 2002 Sep 15;366(Pt 3):889-99.
PMID: 12003638 [PubMed - indexed for MEDLINE]

☐ **89:** Sambongi Y, Nitta H, Ichihashi K, Futai M, Ueda I. Related Articles, Links

A novel water-soluble Hantzsch 1,4-dihydropyridine compound that functions in biological processes through NADH regeneration.
J Org Chem. 2002 May 17;67(10):3499-501.
PMID: 12003566 [PubMed - indexed for MEDLINE]

☐ **90:** Li N, Yi FX, Spurrier JL, Bobrowitz CA, Zou AP. Related Articles, Links

Production of superoxide through NADH oxidase in thick ascending limb of Henle's loop in rat kidney.
Am J Physiol Renal Physiol. 2002 Jun;282(6):F1111-9.
PMID: 11997328 [PubMed - indexed for MEDLINE]

☐ **91:** Itoh N, Matsuda M, Mabuchi M, Dairi T, Wang J. Related Articles, Links

Chiral alcohol production by NADH-dependent phenylacetaldehyde reductase coupled with in situ regeneration of NADH.
Eur J Biochem. 2002 May;269(9):2394-402.
PMID: 11985623 [PubMed - indexed for MEDLINE]

☐ **92:** Krungkrai J, Kanchanarithisak R, Krungkrai SR, Rochanakij S. Related Articles, Links

Mitochondrial NADH dehydrogenase from Plasmodium falciparum and Plasmodium berghei.

Exp Parasitol. 2002 Jan;100(1):54-61.
PMID: 11971654 [PubMed - indexed for MEDLINE]

☐ **93:** Morre DJ. Related Articles, Links

Preferential inhibition of the plasma membrane NADH oxidase (NOX) activity by diphenyleneiodonium chloride with NADPH as donor.
Antioxid Redox Signal. 2002 Feb;4(1):207-12.
PMID: 11970854 [PubMed - indexed for MEDLINE]

☐ **94:** O'Flaherty CM, Beorlegui NB, Beconi MT. Related Articles, Links

Lactate dehydrogenase-C4 is involved in heparin- and NADH-dependent bovine sperm capacitation.
Andrologia. 2002 Apr;34(2):91-7. Erratum in: Andrologia. 2002 Dec;34(6):405.
PMID: 11966575 [PubMed - indexed for MEDLINE]

☐ **95:** Tendi EA, Bosetti F, Dasgupta SF, Stella AM, Drieu K, Rapoport SI. Related Articles, Links

Ginkgo biloba extracts EGb 761 and bilobalide increase NADH dehydrogenase mRNA level and mitochondrial respiratory control ratio in PC12 cells.
Neurochem Res. 2002 Apr;27(4):319-23.
PMID: 11958534 [PubMed - indexed for MEDLINE]

☐ **96:** Cho N, Chueh PJ, Kim C, Caldwell S, Morre DM, Morre DJ. Related Articles, Links

Monoclonal antibody to a cancer-specific and drug-responsive hydroquinone (NADH) oxidase from the sera of cancer patients.
Cancer Immunol Immunother. 2002 May;51(3):121-9. Epub 2002 Feb 27.
PMID: 11941450 [PubMed - indexed for MEDLINE]

☐ **97:** Kahn AM, Allen JC, Zhang S. Related Articles, Links

Insulin increases NADH/NAD+ redox state, which stimulates guanylate cyclase in vascular smooth muscle.
Am J Hypertens. 2002 Mar;15(3):273-9.
PMID: 11939620 [PubMed - indexed for MEDLINE]

☐ **98:** Kao MC, Di Bernardo S, Matsuno-Yagi A, Yagi T. Related Articles, Links

Characterization of the membrane domain Nqo11 subunit of the proton-translocating NADH-quinone oxidoreductase of Paracoccus denitrificans.
Biochemistry. 2002 Apr 2;41(13):4377-84.
PMID: 11914084 [PubMed - indexed for MEDLINE]

☐ **99:** Barquera B, Hellwig P, Zhou W, Morgan JE, Hase CC, Gosink KK, Nilges M, Bruesehoff PJ, Roth A, Lancaster CR, Gennis RB. Related Articles, Links

Purification and characterization of the recombinant Na(+)-translocating NADH:quinone oxidoreductase from Vibrio cholerae.
Biochemistry. 2002 Mar 19;41(11):3781-9.
PMID: 11888296 [PubMed - indexed for MEDLINE]

☐ **100:** Chueh PJ, Kim C, Cho N, Morre DM, Morre DJ. Related Articles, Links

Molecular cloning and characterization of a tumor-associated, growth-related, and time-keeping hydroquinone (NADH) oxidase (tNOX) of the HeLa cell surface.
Biochemistry. 2002 Mar 19;41(11):3732-41.
PMID: 11888291 [PubMed - indexed for MEDLINE]

☐ **101:** MacDonald MJ, Kelley PC, Laclau M. Related Articles, Links

Histochemical evidence for pathways insulin cells use to oxidize glycolysis-derived NADH.
Metabolism. 2002 Mar;51(3):318-21.
PMID: 11887167 [PubMed - indexed for MEDLINE]

☐ **102:** Lemeshko VV. Related Articles, Links

Cytochrome c sorption-desorption effects on the external NADH oxidation by mitochondria: experimental and computational study.
J Biol Chem. 2002 May 17;277(20):17751-7. Epub 2002 Mar 8.
PMID: 11886867 [PubMed - indexed for MEDLINE]

☐ **103:** Bottcher B, Scheide D, Hesterberg M, Nagel-Steger L, Friedrich T. Related Articles, Links

A novel, enzymatically active conformation of the Escherichia coli NADH:ubiquinone oxidoreductase (complex I).
J Biol Chem. 2002 May 17;277(20):17970-7. Epub 2002 Mar 5.
PMID: 11880370 [PubMed - indexed for MEDLINE]

☐ **104:** Kim C, Crane FL, Faulk WP, Morre DJ. Related Articles, Links

Purification and characterization of a doxorubicin-inhibited NADH-quinone (NADH-ferricyanide) reductase from rat liver plasma membranes.
J Biol Chem. 2002 May 10;277(19):16441-7. Epub 2002 Mar 1.
PMID: 11875069 [PubMed - indexed for MEDLINE]

☐ **105:** Pantano S, Alber F, Lamba D, Carloni P. Related Articles, Links

NADH interactions with WT- and S94A-acyl carrier protein reductase from Mycobacterium tuberculosis: an ab initio study.
Proteins. 2002 Apr 1;47(1):62-8.
PMID: 11870865 [PubMed - indexed for MEDLINE]

☐ **106:** Janiszewski M, Souza HP, Liu X, Pedro MA, Zweier JL, Laurindo FR. Related Articles, Links

Overestimation of NADH-driven vascular oxidase activity due to lucigenin artifacts.
Free Radic Biol Med. 2002 Mar 1;32(5):446-53.
PMID: 11864784 [PubMed - indexed for MEDLINE]

☐ **107:** Fang J, Beattie DS. Related Articles, Links

Novel FMN-containing rotenone-insensitive NADH dehydrogenase from Trypanosoma brucei mitochondria: isolation and characterization.
Biochemistry. 2002 Mar 5;41(9):3065-72.
PMID: 11863445 [PubMed - indexed for MEDLINE]

☐ **108:** Nakashima Y, Shinzawa-Itoh K, Watanabe K, Naoki K, Hano N, Yoshikawa S. Related Articles, Links

Steady-state kinetics of NADH:coenzyme Q oxidoreductase isolated from bovine heart mitochondria.
J Bioenerg Biomembr. 2002 Feb;34(1):11-9.
PMID: 11860176 [PubMed - indexed for MEDLINE]

☐ **109:** Papa S, Sardanelli AM, Scacco S, Petruzzella V, Technikova-Dobrova Z, Vergari R, Signorile A. Related Articles, Links

The NADH: ubiquinone oxidoreductase (complex I) of the mammalian

respiratory chain and the cAMP cascade.
J Bioenerg Biomembr. 2002 Feb;34(1):1-10. Review.
PMID: 11860175 [PubMed - indexed for MEDLINE]

☐110: Steuber J, Rufibach M, Fritz G, Neese F, Dimroth P. Related Articles, Links

Inactivation of the Na+-translocating NADH:ubiquinone oxidoreductase from Vibrio alginolyticus by reactive oxygen species.
Eur J Biochem. 2002 Feb;269(4):1287-92.
PMID: 11856363 [PubMed - indexed for MEDLINE]

☐111: Scheide D, Huber R, Friedrich T. Related Articles, Links

The proton-pumping NADH:ubiquinone oxidoreductase (complex I) of Aquifex aeolicus.
FEBS Lett. 2002 Feb 13;512(1-3):80-4.
PMID: 11852056 [PubMed - indexed for MEDLINE]

☐112: Voronina S, Sukhomlin T, Johnson PR, Erdemli G, Petersen OH, Tepikin A. Related Articles, Links

Correlation of NADH and Ca2+ signals in mouse pancreatic acinar cells.
J Physiol. 2002 Feb 15;539(Pt 1):41-52.
PMID: 11850500 [PubMed - indexed for MEDLINE]

☐113: Zhang Q, Piston DW, Goodman RH. Related Articles, Links

Regulation of corepressor function by nuclear NADH.
Science. 2002 Mar 8;295(5561):1895-7. Epub 2002 Feb 14.
PMID: 11847309 [PubMed - indexed for MEDLINE]

☐114: Lancien M, Martin M, Hsieh MH, Leustek T, Goodman H, Coruzzi GM. Related Articles, Links

Arabidopsis glt1-T mutant defines a role for NADH-GOGAT in the non-photorespiratory ammonium assimilatory pathway.
Plant J. 2002 Feb;29(3):347-58.
PMID: 11844111 [PubMed - indexed for MEDLINE]

☐115: Joet T, Cournac L, Peltier G, Havaux M. Related Articles, Links

Cyclic electron flow around photosystem I in C(3) plants. In vivo control by the redox state of chloroplasts and involvement of the NADH-dehydrogenase complex.
Plant Physiol. 2002 Feb;128(2):760-9.
PMID: 11842179 [PubMed - indexed for MEDLINE]

☐116: Ammendola R, Ruocchio MR, Chirico G, Russo L, De Felice C, Esposito F, Russo T, Cimino F. Related Articles, Links

Inhibition of NADH/NADPH oxidase affects signal transduction by growth factor receptors in normal fibroblasts.
Arch Biochem Biophys. 2002 Jan 15;397(2):253-7.
PMID: 11795879 [PubMed - indexed for MEDLINE]

☐117: Reynolds CM, Meyer J, Poole LB. Related Articles, Links

An NADH-dependent bacterial thioredoxin reductase-like protein in conjunction with a glutaredoxin homologue form a unique peroxiredoxin (AhpC) reducing system in Clostridium pasteurianum.
Biochemistry. 2002 Feb 12;41(6):1990-2001.
PMID: 11827546 [PubMed - indexed for MEDLINE]

☐ **118:** Morre DJ, Lawler J, Wang S, Keenan TW, Morre DM. Related Articles, Links

Entrainment in solution of an oscillating NADH oxidase activity from the bovine milk fat globule membrane with a temperature-compensated period length suggestive of an ultradian time-keeping (clock) function.
Biochim Biophys Acta. 2002 Feb 10;1559(1):10-20.
PMID: 11825584 [PubMed - indexed for MEDLINE]

☐ **119:** Kim YK, Lee MS, Son SM, Kim IJ, Lee WS, Rhim BY, Hong KW, Kim CD. Related Articles, Links

Vascular NADH oxidase is involved in impaired endothelium-dependent vasodilation in OLETF rats, a model of type 2 diabetes.
Diabetes. 2002 Feb;51(2):522-7.
PMID: 11812764 [PubMed - indexed for MEDLINE]

☐ **120:** Cook SA, Shiemke AK. Related Articles, Links

Evidence that a type-2 NADH:quinone oxidoreductase mediates electron transfer to particulate methane monooxygenase in methylococcus capsulatus.
Arch Biochem Biophys. 2002 Feb 1;398(1):32-40.
PMID: 11811946 [PubMed - indexed for MEDLINE]

☐ **121:** Higuchi T, Takeda Y, Hashimoto M, Nagano O, Hirakawa M. Related Articles, Links

Dynamic changes in cortical NADH fluorescence and direct current potential in rat focal ischemia: relationship between propagation of recurrent depolarization and growth of the ischemic core.
J Cereb Blood Flow Metab. 2002 Jan;22(1):71-9.
PMID: 11807396 [PubMed - indexed for MEDLINE]

☐ **122:** Fontaine L, Meynial-Salles I, Girbal L, Yang X, Croux C, Soucaille P. Related Articles, Links

Molecular characterization and transcriptional analysis of adhE2, the gene encoding the NADH-dependent aldehyde/alcohol dehydrogenase responsible for butanol production in alcohologenic cultures of Clostridium acetobutylicum ATCC 824.
J Bacteriol. 2002 Feb;184(3):821-30.
PMID: 11790753 [PubMed - indexed for MEDLINE]

☐ **123:** Didion SP, Faraci FM. Related Articles, Links

Effects of NADH and NADPH on superoxide levels and cerebral vascular tone.
Am J Physiol Heart Circ Physiol. 2002 Feb;282(2):H688-95.
PMID: 11788419 [PubMed - indexed for MEDLINE]

☐ **124:** Nakamaru-Ogiso E, Yano T, Ohnishi T, Yagi T. Related Articles, Links

Characterization of the iron-sulfur cluster coordinated by a cysteine cluster motif (CXXCXXXCX27C) in the Nqo3 subunit in the proton-translocating NADH-quinone oxidoreductase (NDH-1) of Thermus thermophilus HB-8.
J Biol Chem. 2002 Jan 18;277(3):1680-8. Epub 2001 Nov 9.
PMID: 11704668 [PubMed - indexed for MEDLINE]

Display Summary Show 200 Sort by Send to

Sep 5 2006 08:10:00